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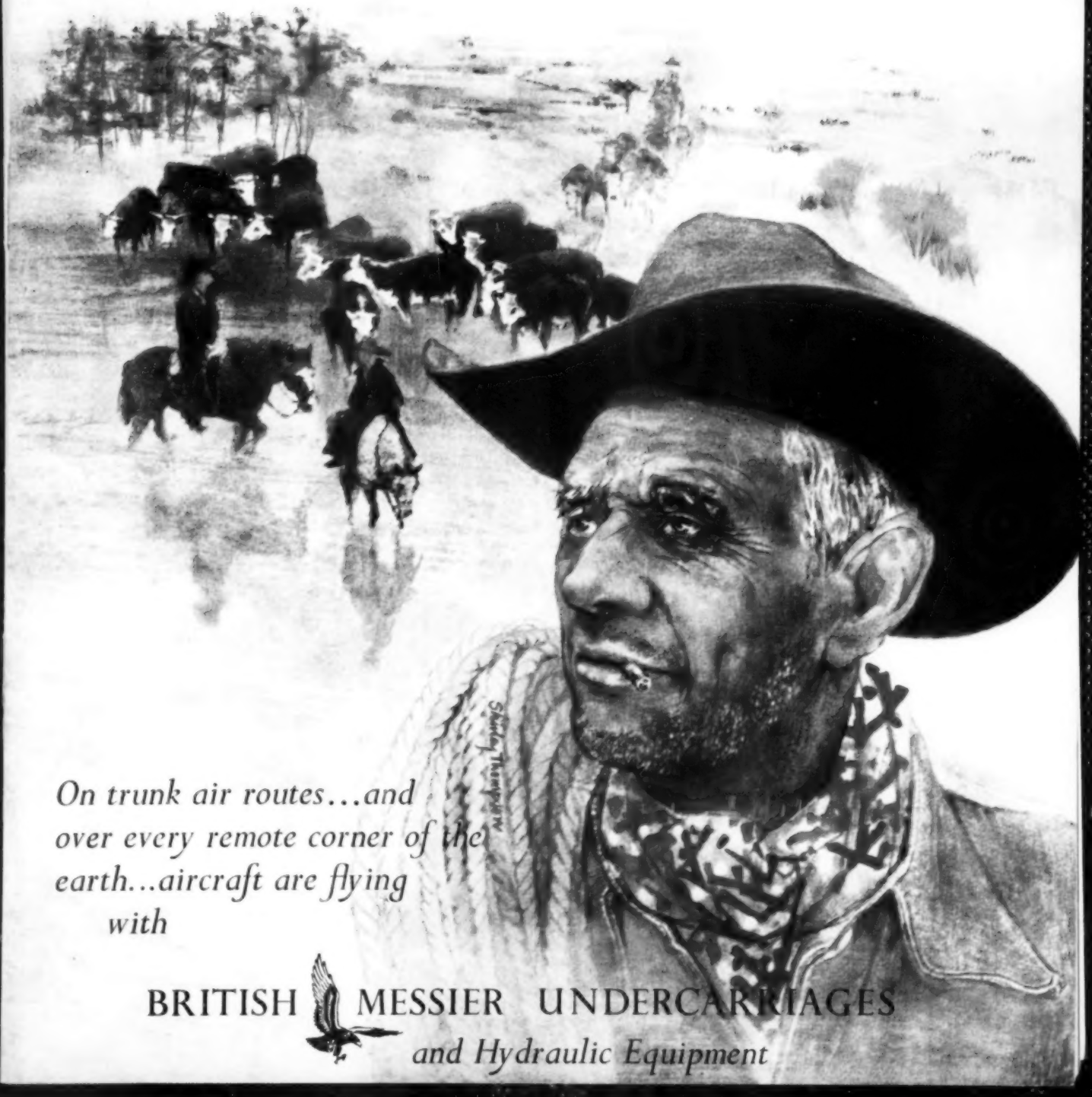
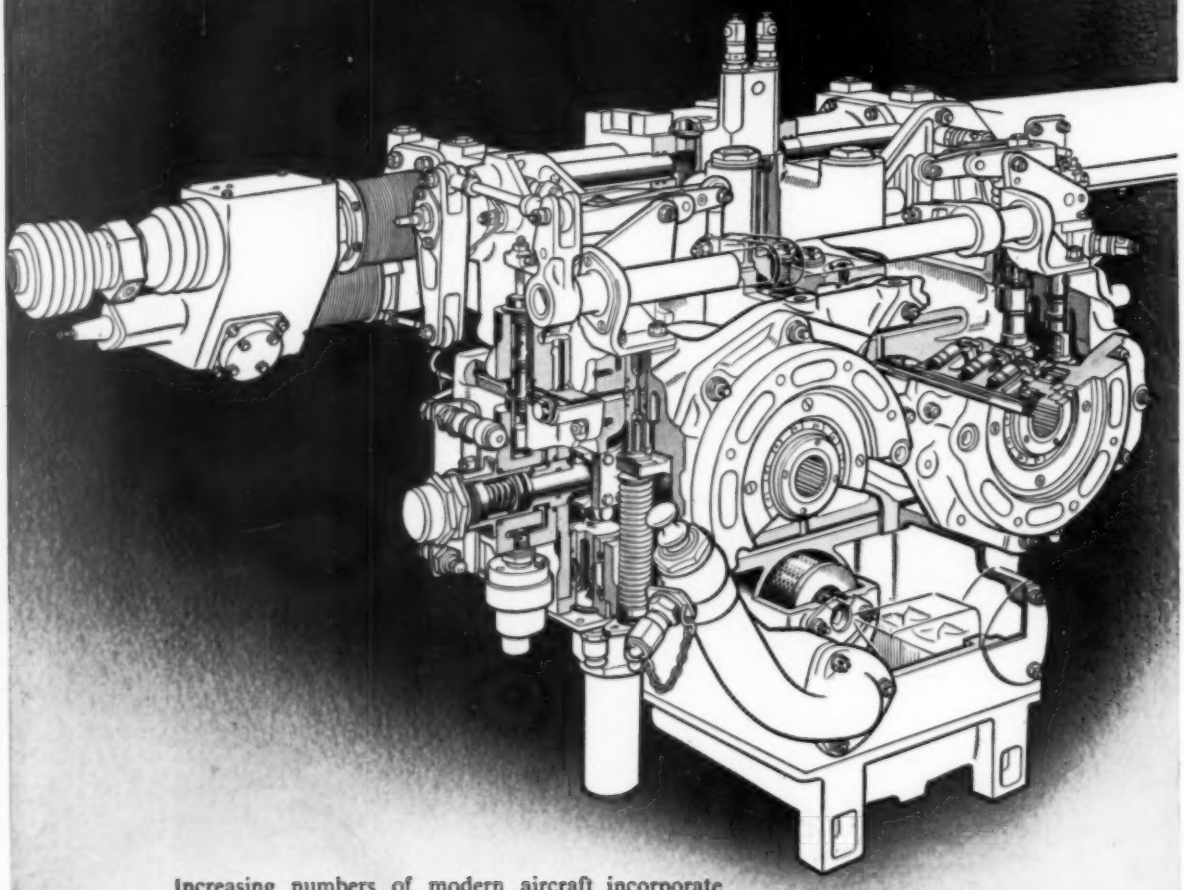


# Power Control



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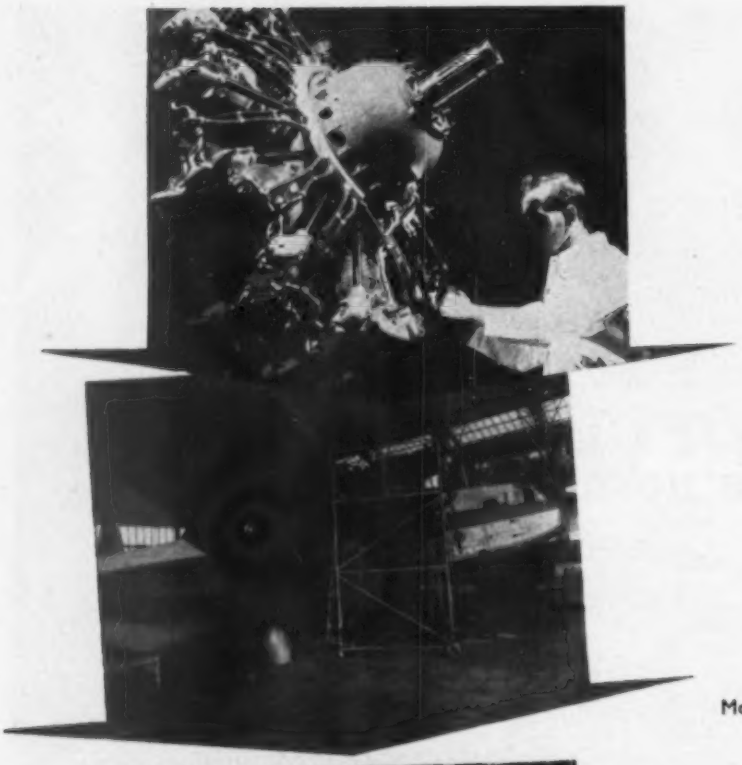

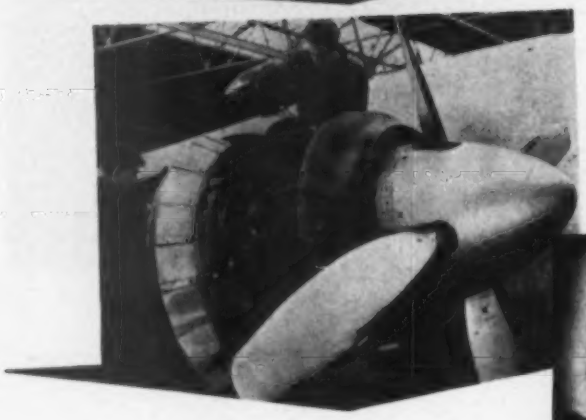

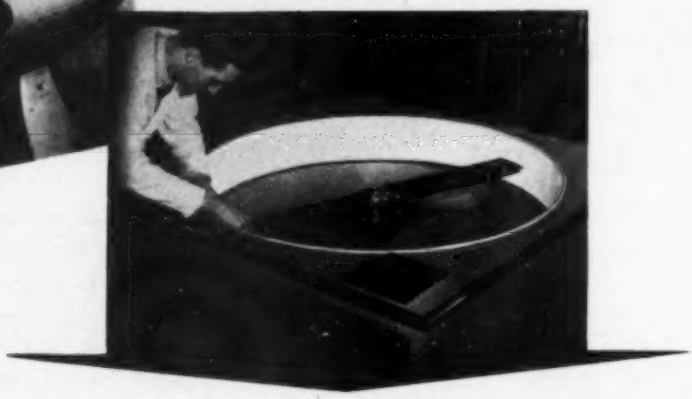

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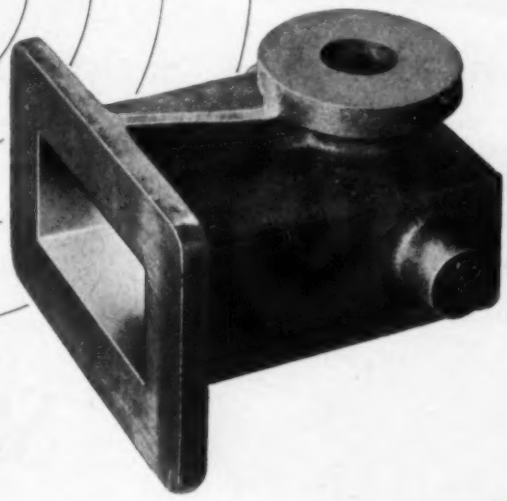

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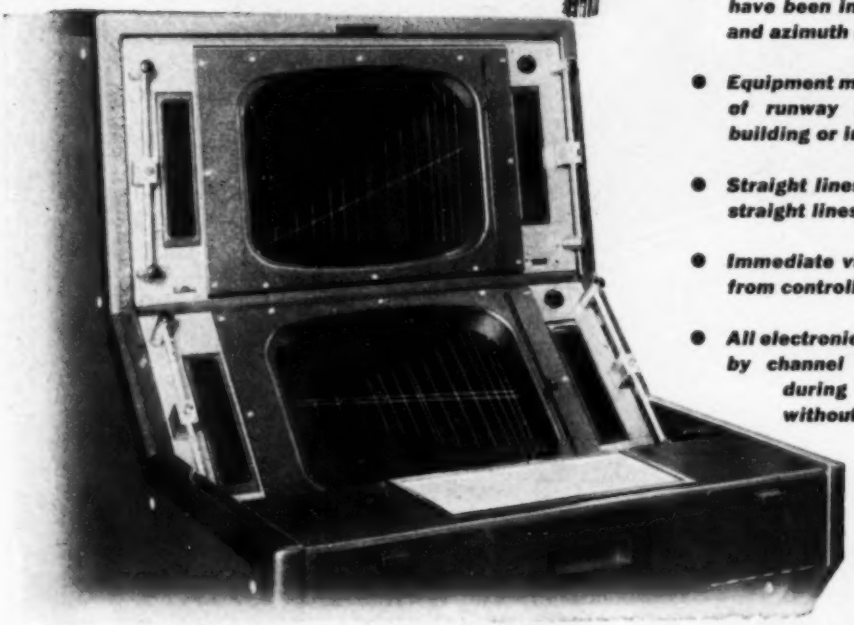

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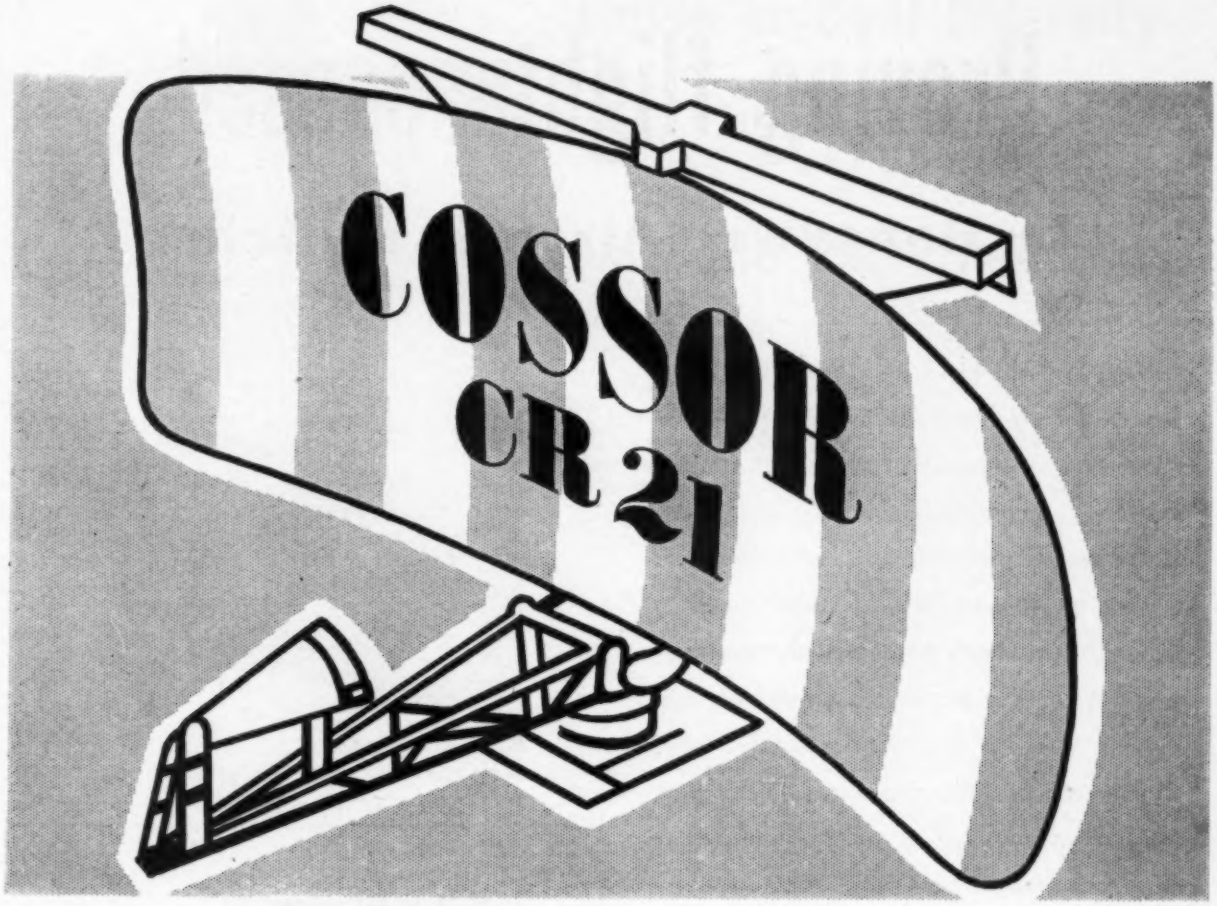


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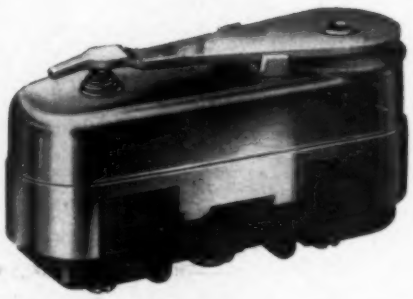

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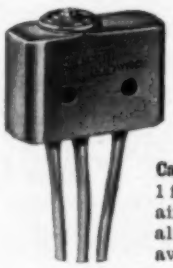

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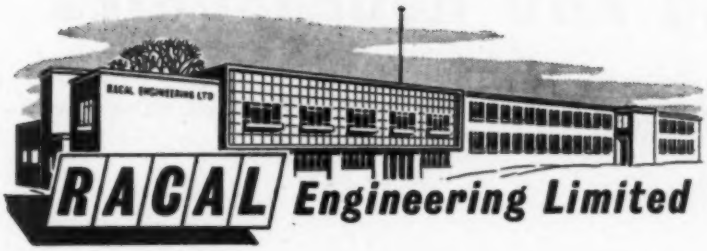


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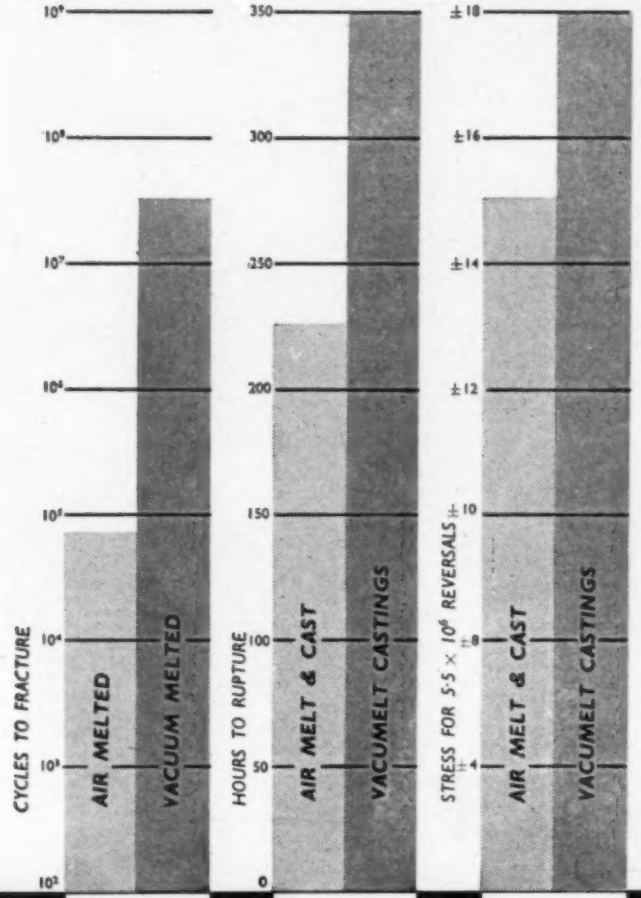


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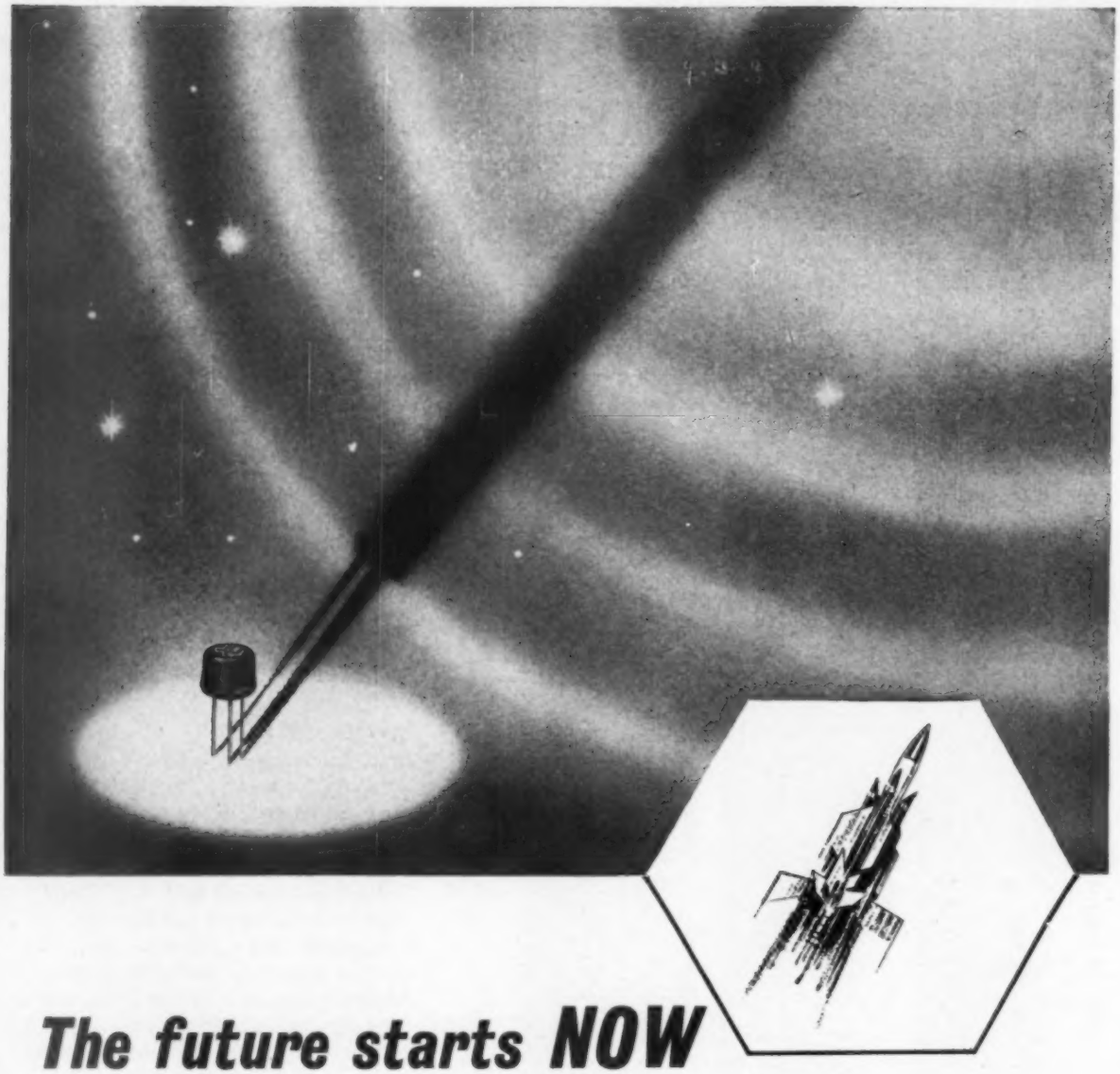

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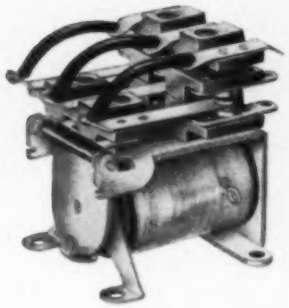

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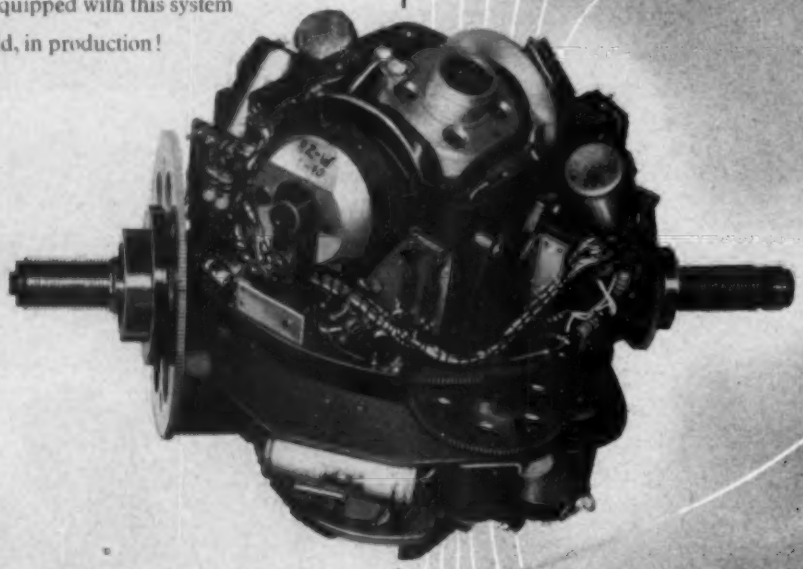

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**You ought to... or any other Pilot for that matter. Hang it all, man, it's a really first-rate British development and it's going to be a big help to aircraft designers like myself.**

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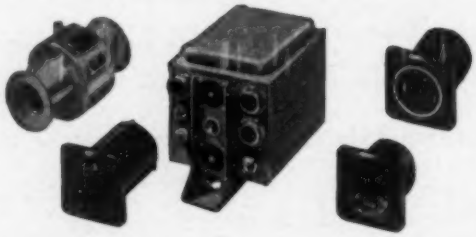

CRCI FL

*Feats of Hercules*

# FROM THE SNOWS OF FUJIYAMA TO THE SANDS OF FLORIDA

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# "We are Extremely Pleased with the VULCAN"

These words of the Air Officer Commanding No. 1 Group, Bomber Command, summarise the fine impression the Avro Vulcan has created in its first year of service with the Royal Air Force. Commenting on the fine performance of the Vulcan "both from the operating and the maintenance aspects", he went on to say: "The way in which the large aircraft and its complex system has been brought into use in the front line of Bomber Command, without any of the enforced groundings so frequently experienced with new types of aircraft, is most gratifying." Popular with air and ground crews alike, the Avro Vulcan—almost certainly the world's fastest and most effective operational bomber—has become in one short year the spearhead of Britain's air power.

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## Prospect—

IT was a typically courageous and imaginative idea on the part of the Air Council to put R.A.F. policy and views squarely before the public in the form of the recent conference called "Prospect Two" (report, p. 688). To see pairs of surprisingly young-looking air commodores and group captains striding down Whitehall Place on the morning of May 6 towards the Royal Empire Society, mingling at its doors with industrialists, churchmen, school teachers, city fathers and M.P.s; and then to listen to this civilian audience quiz the Service on the policies it presented, in the style of an American president's Press conference, was to enjoy a rare and refreshing experience. But once the exhilaration of the day was over—of seeing the whole R.A.F. marshalled, so to speak, at one view—certain questions at once presented themselves. Was it worthwhile to hold such a conference at all? Would the R.A.F. gain from this sounding-board of public opinion, seeing that so little time could be allowed for discussion when so much ground had to be covered in a single day? Was it right that the R.A.F. should express views (about manned aircraft) that seemed at variance with the Defence White Papers? And finally, is a Service justified in using a public forum (apparently, if not intentionally, by-passing Parliament) and appearing to seek what amounts to a popular vote of confidence?

Much of what was said during the day was already common knowledge, at least to those reasonably acquainted with the R.A.F. and with aviation in general. It was not until A.V-M. Kyle's paper in mid-afternoon that the bolts really began to fly from the blue. His exposition of R.A.F. thinking on its immediate and future requirements was a striking piece of bold philosophy based both on experience and on forethought; and unless the day was going to be incomplete, one could hardly have expected the chief of operational requirements to say other than he did. But A.V-M. Kyle's reasoned advocacy of the case for more manned aircraft—"if," be it noted, "we find a reliable defence against the ballistic missile"—subsequently aroused a controversy which stemmed largely from an over-simplification and misunderstanding of that part of his address.

### —and Policy

The key to his remarks was to be found in the phrase that "circumstances change fairly rapidly"—for of no sphere is this more true than of the air; nor are Ministry of Defence decisions like the laws of the Medes and Persians; and the R.A.F. would not be worthy of public confidence if it did not look ahead and honestly base its plans on the changing picture of air power as far as possibly can be foreseen. Underlying the views which had been so cogently expressed was the closing remark by the Chief of Air Staff that the R.A.F.'s task would be immeasurably simplified by the confidence of the British public.

It was to engage that confidence that Prospect Two was held. The youngest Service, at a time when we are in the middle of a revolution in air power, decided to put its views and explain its workings to a representative cross-section of the British people. There is no justification for suggesting that the conference was a sinister attempt to outflank the Cabinet. Some might say that it was a waste of time, or that nothing was gained; and perhaps the tangible results will be small, though the C.A.S. promised that all views put forward would be carefully considered. Some might quarrel with the method of presentation, considering the dramatic presentations an over-simplified technique; others would side with the Mayor of Aylesbury when he summed the conference up as "a courageous experiment." (Perhaps, indeed, it is one which might be more widely tried.) No doubt the R.A.F. has many battles still to fight; not, we trust, Battles of Britain but possibly battles with the Ministry of Defence. At the Royal Empire Society the R.A.F. flexed its muscles on neutral ground. It has shown that it has the courage to change its mind where it considers need so dictates; and it has surely by Prospect Two at least gained public sympathy not only for the flexibility of its views but also for its honest and well-thought-out method of expressing them.

# FROM ALL QUARTERS

*BADGE OF OFFICE is handed over at the Royal Aeronautical Society's a.g.m. by Sir George Edwards, retiring president, to his successor, Sir Arnold Hall.*

"Flight" photograph

## A New Height Record

ON May 7 a Lockheed F-104A Starfighter of the 83rd Fighter/Intercepter Sqn., U.S.A.F., climbed to an observed height of 91,249ft. The pilot was Maj. Howard C. Johnson, the 83rd's operations officer; he was airborne (operating from Palmdale, Cal.) for 27 minutes. The new figure is particularly meritorious because the F-104 was fully equipped and powered solely by a turbojet—a G.E. J79.

## Venom Successor?

VENOMS based at Aden made rocket and cannon attacks on May 6 and 7 against a semi-fortified barracks a mile inside Yemen territory, and for some time past used as a main base for attacks against the Protectorate.

Mr. Charles Orr-Ewing, Under-Secretary of State for Air, said on May 7 that the Folland Gnat was being seriously considered as a successor to the Venom. Operational trials of the Gnat and other possible successors would be held in Aden shortly.

## Hiller Rotorcycle in Britain

THE first free-flying Hiller XROE-1 Rotorcycle, now visiting Britain, was demonstrated in London last Tuesday. Some 60 hours' flying have been completed, ten of them in Europe, and there is a possibility of a NATO order from a combine of licensed companies. First step towards civil certification will be acceptance of the single-ignition, two-stroke, 42 h.p. Nelson engine, which has the low weight of 45 lb. Initial cost of production machines would be about £4,000, which might later be reduced to about £2,000. The XROE-1 was joint winner with Gyrodyne of a U.S. Marine Corps design competition for an air-droppable helicopter. A photograph appears opposite.

## D.H. Propellers Accessories

IT is announced that de Havilland Propellers, Ltd., are in production with both cold-air units and small alternators. The latter, with outputs ranging from a few hundred watts to several kVA, can supply frequency and voltage within ±1 per cent under arduous conditions, and many have integral motors operated by a variety of hydraulic or gas supplies. D.H. alternators are standard on the Bloodhound, Seaslug and Firestreak and are used in the P.1B, Javelin and Sea Vixen. The company's cold-air units are incorporated in the main conditioning systems of the Comet 4, P.1B, Scimitar, Sea Vixen and Victor B.1, and packaged units are also employed in the last-named aircraft to feed the crew's ventilated suits. The Sea Vixen unit has a unique sealed lubrication system and an overhaul life of 250 hr, without servicing.

## Vickers-Wallis Research

MUCH fiction—and some fact—has appeared in the newspapers about supersonic research which has for many years been in hand at Weybridge under the direction of Dr. Barnes N. Wallis, chief of research and development of Vickers-Armstrongs (Aircraft), Ltd. The project—intended to lead to a supersonic-cruise bomber—incorporated ingenious features, two of which were an arrangement of varying wing sweep through a large angle and of cooling the airframe. All these have been patented, but as the work was undertaken against an M.o.S. research contract no details may be published.

Last August Vickers were informed that the Government could not afford to finance the work further; but the potentialities are so great that discussions are now taking place with a view to international sponsorship. Conferences have been held to determine NATO interest and the practicability of further research under the sponsorship of the U.S. Mutual Weapons Development Program. On May 9 a team led by Mr. Richard E. Horner, assistant secretary (R. and D.) of the U.S. Air Force, held discussions and were shown, *inter alia*, films of free-flight models.

## Marconi Show off their Doppler

ON page 662 of this special Flying Aids issue of *Flight* is described Britain's first Doppler navigation system to be offered for civil use—the Marconi AD.2300 series. Last week Marconi completed what appears to have been a remarkably successful European demonstration tour with this equipment.

Most airlines still tend to regard Doppler as highly promising technically, but still around the corner operationally. Marconi's tour will have done much to banish this misconception. Their demonstration aircraft was an Airwork Viking, specially modified by Airwork Services, Ltd., whose airline division undertook also the actual demonstrations. These were given in Paris, Rome, Zurich, Stockholm, Amsterdam, Cologne and Brussels, and were witnessed by government authorities, airlines, and representatives of Europe's aircraft industry. The tour, which started on April 28, lasted for ten days; and last week at Blackbushe *Flight* witnessed the final series of demonstrations to British operators, Government departments and Service officers. The accuracy of the Marconi Doppler, which had a special display panel mounted in the Viking's cabin, was most convincingly demonstrated.

## R.Ae.S. Awards

AT the a.g.m. of the Royal Aeronautical Society, held on May 8, awards were presented for papers published by the Society, and the new president (picture above) also took office. Last night, May 15, on the occasion of the Wilbur Wright Lecture (summarized on page 658), the major awards—including honorary fellowships and gold and silver medals—were to be presented.

The awards for published papers were as follows:—

**Simms Gold Medal** (for a contribution on any subject allied to aeronautics): Mr. L. F. Nicholson, head of the aerodynamics department at the R.A.E. Farnborough, for his paper *Engine-airframe Integration*; **George Taylor (of Australia) Gold Medal** (for a contribution on aircraft design, manufacture or operation): Mr. R. L. Lickley and Mr. L. P. Twiss for their paper *The Fairey Delta 2*; **Edward Busk Memorial Prize** (for a contribution on applied dynamics): Dr. D. Kuchemann, a senior principal scientific officer at the R.A.E. Farnborough, for his paper entitled *Methods of Reducing the Transonic Drag of Swept-back Wings at Zero Lift*.

**Orville Wright Prize** (for a contribution to the Society's *Aeronautical Quarterly* on a technical subject connected with aerodynamics): Professor A. R. Collar, professor of aeronautical engineering in the University of Bristol, for his paper on *The Stability of Accelerated Motion—Some Thoughts on Linear Differential Equations with Variable Co-efficients*; **Herbert Ackroyd Stuart Memorial Prize** (for a contribution to the Society's publications on aircraft propulsion): Dr. R. R. Jamison, assistant chief engineer in charge of ramjets at Bristol Aero-Engines Ltd., for his paper on *Ramjets*; **J. E. Hodgson Prize** (for a paper of a general nature, with emphasis on historical work): Professor J. H. van der Maas, professor of aeronautical science at Delft University, for his paper on *Aeronautical Research in the Netherlands*.

**Branch Prize** (for a paper on an aeronautical subject read before the branches): the prizewinning paper was the Roy Chadwick Memorial Lecture read before the Manchester branch by Mr. M. B. Morgan, one of the two deputy directors of the R.A.E. Farnborough, on *Some Thoughts on Aeronautical Research and Design*; **Navigation Prize** (for a paper on navigation, including meteorological instruments and test equipment): Mr. W. Makinson and Mr. G. M. Hellings, respectively managing director and chief engineer of Air Trainers Link, Ltd., for their paper on *Synthetic Aids to Flying Training*; and the **Usborne Memorial Prize** (for a graduate or student contribution on a technical subject connected with aeronautics): Mr. D. G. Drake, a graduate of the Society and a lecturer in the Department of Aeronautical Engineering at the University of Southampton, for his paper on *The Oscillating Two-dimensional Aerofoil Between Porous Walls*.

## O.U.A.S. Gathering

AS brilliant a gathering of Service and university personalities as can ever have been assembled at one of these functions was seen at Oxford University Air Squadron's annual dinner last Friday. Wardens, presidents, rectors and principals of many colleges joined the Vice-Chancellor, Mr. J. C. Masterman, in the toast to the Squadron, and the C.A.S., Marshal of the R.A.F. Sir Dermot Boyle, replied on behalf of the guests. Service guests included Air Chief Marshals Sir Leslie Hollinghurst and Sir Walter Dawson; Air Marshals Sir Edmund Hudleston, Sir Douglas Macfadyen and Sir Geoffrey Tuttle; A.V-M.s W. F. MacNeece Foster and V. S. Bowling; A. Cdres. N. C. Hyde (Commandant of the C.F.S.) and A. E. Clouston (A.O.C. Boscombe Down); the Rev. Canon A. S. Giles (Chaplain-in-Chief of the R.A.F.) and every former O.U.A.S. commanding officer since 1945.

In welcoming the guests, the present C.O., W/C. A. J. Douch, pointed out that he had held this command for only fourteen days. He had himself come up to Oriel in 1936 at the same time as Mr. K. C. Turpin, present that evening as Provost of Oriel. Expressing the oft-repeated hope that the squadron might receive some operational trainers to supple-

*THINGS TO COME: Equipment being developed for the Royal Navy was seen by Lord Selkirk, First Lord of the Admiralty, during a visit last week to Flight Refuelling, Ltd. In this group are, l. to r., Lady Selkirk, W/C. H. C. Johnson (F.R. general services executive), Lord Selkirk, Sir Alan Cobham (F.R. managing director) and Lady Cobham.*

*APPOINTED TO THE BOARD of Scottish Aviation, Ltd., as deputy chairman is Mr. Bernard Boxall, B.Sc., A.C.G.I., M.I.Mech.E., M.I.Prod.E., deputy mg. dir. of Production Engineering, Ltd.*

ment its Chipmunks, W/C. Douch thought that the apparent run-down in the number of operational aircraft might now make this more probable. The C.A.S. reaffirmed R.A.F. appreciation of the great importance of the university air squadrons.

Finally, W/C. Douch presented the Hack Trophy, for the best all-round member, to I. W. Rixon, of University College, and the Flying Proficiency Trophy (presented in 1933 by Sir John Siddeley) to J. T. R. Coburn. There was no prize, the C.O. remarked, for the member who had navigated him the wrong way up a one-way street on the first day of term.

## The Pathfinders Dine

PATHFINDER Association annual dinners are light-hearted occasions during which, however, the principal Service guests frequently take a few minutes in which to comment on topical matters of importance. The thirteenth, held at the Dorchester Hotel, London, on May 7, went according to plan and custom.

The warm sincerity of Colonel Richard Curtis' toast to the R.A.F. was much appreciated. He spoke of the links with the American air forces, and added that the free nations of the world could become bankrupt by trying to match quantitatively the tremendous forces of potential enemies; we must seek to best them qualitativewise.

Replying, Air Chief Marshal Sir Walter Dawson, Air Member for Supply and Organization, commented that the P.F.F. badge was the only one of its kind; no one could dilute it by earning it afterwards; no top buttons need be left undone; it was peculiarly the Pathfinders'.

Referring to a recent short course that he had himself taken with the V-bomber force, he said he had been impressed particularly by the tremendous amount of ground-school work that had to be done "before they would even let you near an aircraft in Bomber Command." He said that there would be plenty of flying, not only for the next ten years but as long as he could foresee; and he wondered if it was clear that ballistic missiles were coming in as an integral part of Bomber Command.

It was also his belief that Transport Command was definitely on the up and up. Was it appreciated that the Command was the only world-wide jet operator? He had been most impressed with the wonderful job the Beverley had done in taking all manner of equipment into the small strips in the Aden Protectorate. Flying Training Command, too, was still a jump ahead of anyone else in having all-through jet training and the advantage of giving a very early grasp of instrument flying.

The guests were personally, competently and wittily proposed by S/L. A. T. W. Blair. Replying, the V.C.A.S., Air Marshal Sir Edmund Hudleston, commented on the efficiency of Bomber Command and its crews. In a recent surprise alert, he said, the time from bunks to becoming airborne in a V-Bomber at night had been eleven minutes. Readiness was a great problem and an expensive business, but if missiles were going to assail us the time must come down to five minutes.

The R.A.F., continued Sir Edmund, was beginning to learn more about missiles. They were hair-trigger devices, but in practical respects they were like a big aircraft—and with lots of bugs. It would be a mistake to rely on them completely. We needed a greater proportion of manned aircraft, both offensive and defensive. The missile was predictable, but we needed also the unpredictable, as supplied by the human element.

As far ahead as the R.A.F. could foresee there would be a job for aircrew. They would have to spend some time looking after missiles, but these were not dull and inert; a long-range missile had all the components of a modern bomber, so the men responsible would have a lot to do.

# IN BRIEF

The first two squadrons for the new air arm of the West German Navy, both formed in this country and equipped with British aircraft, are due to be commissioned next week—a multi-purpose (Sea Hawk) squadron at Lossiemouth on May 19 and an A.S. squadron (Gannets) at Eglinton on the following day.

* * *

Continental light aircraft, air/sea rescue equipment and models of the Woomera range are likely to be seen at the Royal Aeronautical Society's garden party (members only), to be held at White Waltham on June 22.

* * *

The Fédération Aéronautique Internationale last week formally announced the unanimous election of Miss Jacqueline Cochrane, the famous American woman pilot, as its president for 1958-59. M. Jacques Allez was elected first vice-president, M. Jean Blériot treasurer-general and Dr. Charles Sillevaerts an honorary president. The elections were made at last month's Los Angeles conference.

* * *

Nine U.S.A.F. bases in this country will be opened to the public tomorrow (Saturday, May 17) to mark U.S. Armed Forces' Day. At Alconbury (Hunts) and Bentwaters (Suffolk), the R.A.F. Hunters of No. 111 Sqn. will perform; and the U.S.A.F. "Skyblazers" are also appearing at Alconbury and at Sculthorpe (Norfolk). Other bases on view will be: Bovingdon (Herts.), Burtonwood (Lancs), Shepherds Grove (Suffolk), and Prestwick (Ayrshire). Two non-flying stations will also be open—Bushy Park (Middx) and the U.S.A.F. Hospital, Burderop Park, near Swindon (Wilts).

* * *

Following the news that a Lockheed F.104 Starfighter has established a new world's altitude record by climbing to 91,249ft (see opposite page) comes an announcement from Sud-Aviation that the Trident 2, for which a figure of 80,190ft was recently claimed, will not fly again. Development work has been stopped because of Government economy cuts; but it is reported from Paris that development of the Trident's main competitor, the Dassault Mirage IIIA, will continue.

* * *

The Aircraft Manufacturing Co., Ltd., recently formed by de Havilland, Hunting Aircraft and Fairey Aviation (*Flight*, February 28) has arranged with W/C. R. H. Stocken, managing director of Airco, Ltd., to take over the name Airco. This was the trade name of the Aircraft Manufacturing Company, in which Sir Geoffrey de Havilland's team originated during the 1914-18 war. W/C. Stocken, who had early associations with the company, has agreed to change the name of his own consultancy firm from Airco, Ltd., to R. H. Stocken and Co., Ltd.

*SMALL HELICOPTER: The first of ten Saunders-Roe Skeeters for service with the West German Army and Navy. Powered by a D.H. Gipsy Major 215 engine, the Skeeter is also in quantity production for general duties with the British Army Air Corps.*

*SMALLER HELICOPTER: Dick Beck, Hiller test pilot, flying the XROE-1 at Elstree. Rotor r.p.m. are 540 and engine r.p.m. 4,000; and cruising speed is 55 m.p.h. The machine can be folded and stowed in less than 12ft by 30in. (News item on previous page.)*

"Flight" photograph

# Defense

## A CONDUCTED TOUR OF U.S. AIR POWER

## PART TWO: THE MISSILE-MINDED ARMY

**THIS is the second dispatch (the first appeared in our issue of May 2) from a correspondent who is a member of the party to which the U.S. Armed Services have given special facilities for inspecting their newest equipment and methods. In the previous article he described the journey from England in a C-118 of MATS (Military Air Transport Service) and a visit to the Pentagon for briefing. Here he makes long flights to see missile trials and training at two Army bases.**

THIS time a V.I.P. Convair VC-131 of MATS' special communications squadron at Bolling Air Force Base, Washington, flew up to Wilmington, Delaware, to take us over the length and breadth of the States. The particular aircraft was one originally ordered by Lufthansa, then bought by the U.S.A.F. when the Germans decided they didn't want it. Furnished to normal airline standards, it made a comfortable transport for the long hauls we were to do.

First stop was Lincoln A.F.B., Nebraska. This is a S.A.C. base, littered with B-47s. I counted 40 as we taxied in from the 13,000ft runway; refuelling was one which had landed just before us—after a non-stop flight from Greenham Common, Berkshire.

But we were not yet to be given the opportunity of inspecting a S.A.C. base. The State Department and the Air Force had decided that we must first see some more Americana—this time the sort of town rarely visited by Britons.

Lincoln is a typical mid-Western agricultural centre, State capital of Nebraska, and a thoroughly pleasant city. Even the Warden of the State Penitentiary, inviting us to lunch, put himself out to see that we enjoyed it. If you are a "trusty" in an American gaol you can expect better food and accommodation than the British Army provides for its soldiers. Lunch was in the trusties' cafeteria, a convict band played while we ate, and two tables from me sat a man who had been awarded a sentence of 85 years (but, as the prison magazine pointed out, the term had been reduced to 35 years because of his good behaviour).

In the evening to see another typically American activity—a "pageant" to select Miss Nebraska of 1958. (My personal choice was Miss Lincoln, a pretty 19-year-old university student, but she was pipped at the post. This made me annoyed with the judges—one of whom was the Air Force Base commander.) But this happy dilly-dallying soon ended; and the Convair, turning on to the runway a good third of the way down its length, took off for El Paso, Texas. This was where the real work started—the United States Army took us over to show how it trains its "missile men."

We had our orders: reveille at 0600, and none of this nonsense about coffee-breaks. I had to work hard to become a member of the Ancient and Honorable Order of the Oozlefinch—something familiar about that name—of the A.A. and G.M. (*not* General Motors) Centre of Fort Bliss. The oozlefinch, a fabulous bird, is the mascot of the American gunners.

Fort Bliss trains thousands of men each year in the technique of maintaining and firing Nike Ajax and Nike Hercules. It shares a desert range—of a mere 4,000 square miles—with the White Sands Proving Ground, and the Air Force's Holloman Missile Development Center. WSPG is responsible for research and development, troop trials of the actual hardware and acceptance tests.

***"But the Nike Hercules demonstration was even more exciting . . . the towering missile was fired almost vertically."***

***By a Special Correspondent***

Maj-Gen. W. E. Laidlaw greeted us when we drove the fifty miles from Fort Bliss to WSPG. And he took us out in person to see a Corporal fired. This was the first time any European visitors, other than highly-security-cleared soldiers and government officials, had been given this privilege. We sat on a stand a good half-mile away from the launching site and were briefed by a donnish gunner on what we were to see.

But this Corporal was feeling out of sorts, and after half-an-hour we were told that firing had been postponed because of "a technicality"—we were not told what. So, since this was the Army and we must stick to schedule, we were rushed off to another site to see a Nike Hercules fired. Half-way there, however, a message to a radio car announced that Corporal was again fighting fit and there were five minutes to go to the final count-down.

By then we were five miles away. We piled out of our buses, scrambled up on to another stand (White Sands is littered with them) and waited. Even at that considerable distance it was impressive to see the tall rocket blast almost vertically upward with a great tongue of flame behind it. Then it was gone, leaving only a white vapour trail to show the first part of its trajectory. The range is a hundred miles long (with 1,000 miles of roads and 400 observation posts) and on this occasion Corporal travelled a good two-thirds of that distance.

I was told that our first Royal Artillery regiment to get the Corporal arrives at WSPG in September for range training. British Army technicians who have already been to WSPG were "great guys, fine soldiers and swell to work with."

But the Nike Hercules demonstration was even more exciting. At present the Army has a firing programme of twenty rounds for acceptance trials. The firing we were to see was the fourth round of the series. From Holloman, half-way up and to the east of the range, a converted T-33 drone had become airborne, controlled by two mother ships, one on each side of the range.

Hercules, we were told, will be in the hands of operational troops by June; and the troops will like it much better than they do old Nike Ajax. For, apart from having at least three times the range and twice the ceiling of Ajax, it uses solid fuel. Only the other week a man was badly burned on the neck and back by a spurt of nitric acid from one of the older weapons.

It is to be deployed in Europe as soon as possible. At least two NATO nations will have it before the U.S. Army in Europe converts from Ajax to Hercules for the protection of its installations. Hercules, like Ajax, uses command guidance—a system which the American Army decided to adopt right at the outset of its surface-to-air missile programme. It is planned to have mixed batteries of Ajax and Hercules, for Ajax can be tied in with the more sophisticated, yet simplified, radar system developed for the later missile.

Hercules was ready when we reached the firing point to sit on yet another stand, and the drone was flying up and down the range ready to come in. Said the captain who conducted the briefing: "We've shot down every target offered to us."

The towering missile was fired almost vertically. After 2½ seconds it was supersonic, the four-barrel booster carrying on upward after separation. In front of each site is a "booster impact zone" which has to be clearly defined, for the boosts come down with something of a wallop.

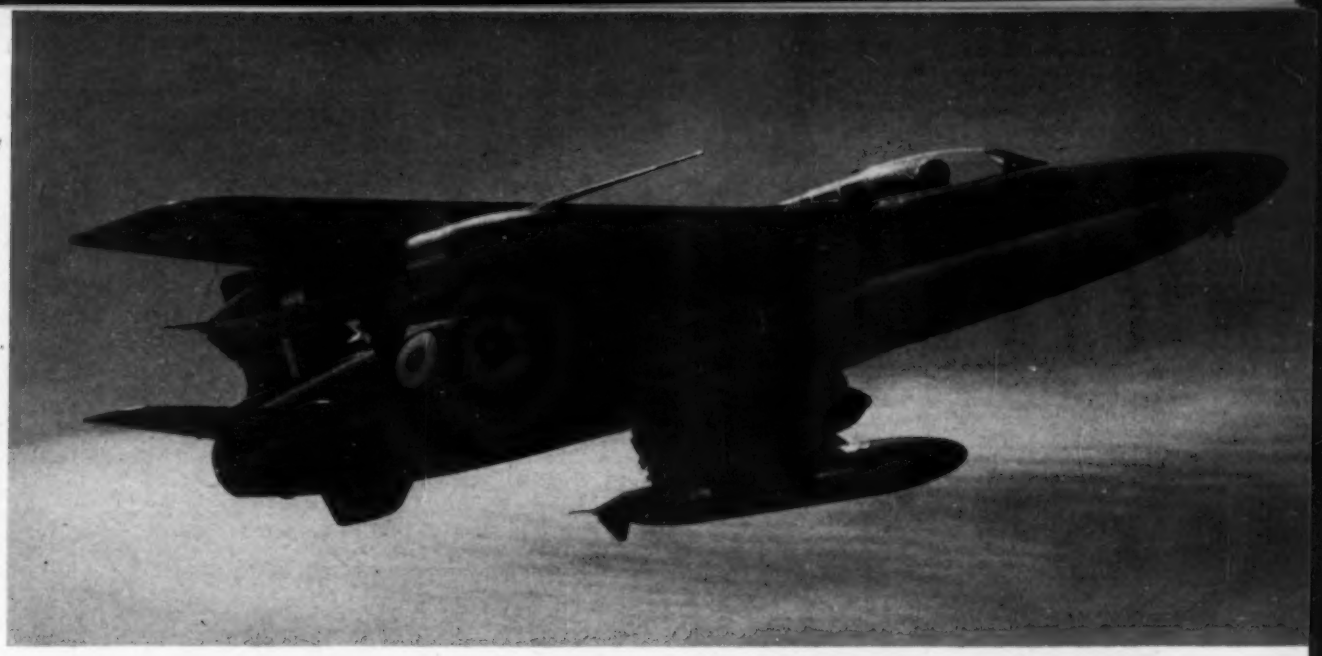
With only a training warhead, Hercules scored a bull. A million dollars' worth of missile and aircraft blew up in a distant burst of smoke and flame.

So back to Fort Bliss, a shower, dinner in the officers' club and a reluctant turn-down of an offer to be escorted round the fleshpots of Juarez, just across the Rio Grande on the Mexican side. For reveille was again at 0600, and we had to do a trip to the northernmost tip of the range.

This was to Red Canyon, where operational troops from Nike sites everywhere come for their annual firing practice. A venerable C-47 carried us from El Paso International to a small concrete strip in the middle of the desert at Oscura, fifteen miles away from the canyon. For a full 50 minutes we flew under VFR at 2,000ft along the eastern border of the range, passing over Holloman on the way. (At Holloman, you will remember, the Air Force medicos do such unpleasant things as supersonic sled rides and trips in highly claustrophobic gondolas slung from balloons. They also test Maces and Matadors there; but the base was not on our schedule, and the Dakota flew sedately by.)

We were not the only guests at the isolated firing camp at Red Canyon. We were to see rounds fired by a battery from a site in

*(Concluded at foot of opposite page)*



## "A genus of dipterous insects of numerous species"

THIS is the definition of "gnat" as given by Chambers's 20th Century Dictionary; and the Gnats of Folland production promise to be equally prolific in their variations. Above is Ministry of Supply Gnat XK741 carrying two 500 lb bombs and two of the latest Folland 66-gal drop tanks. The latter are modified Bristol asbestos-phenolic tanks, and are being used to test the aerodynamic qualities of the new shape. Eventually they will be of all-metal construction. The second picture is of an Indian Gnat, which will shortly be engaged in tropical trials and is instrumented accordingly, though otherwise an operational aircraft. It carries radar-ranging equipment and a radio compass. The rear-view windows have been deleted, as have the small ram-air intakes at the roots which are visible on the M.o.S. machines. The earlier type of drop-tank is carried.

**DEFENSE** (Continued from opposite page)

New Jersey, and just to show the local citizens how they could depend on the Army to defend them from air attack, the authorities had flown fourteen good citizens from New York to see how it was done. They were briefed on Ajax and Hercules, told that Hercules can shoot down any operational aircraft that can be built, that Ajax can look after any present operational aircraft and some aerodynamically supported missiles as well, that Hercules can take care of "certain types of other devices," that 3,000 Ajax missiles have been fired (many times that number have been built), and that when Zeus came along the anti-missile-missile age would have been reached.

The citizens were, of course, impressed. This happens every week, as batteries come to Red Canyon from different parts of America. Incidentally, the range is also used for the annual training of Corporal units deployed in Europe.

The "shoot" we were to see was organized on a competitive basis. The battery is given thirty minutes' warning of action, then has twenty seconds to find and lock-on to its target. A burst under 75 yd from the target is considered a satisfactory round. Points scored for these things, and for general efficiency, produce a fine bit of morale-boosting for troops who have a static job under aggravating conditions amounting almost to inactivity.

Targets used at Red Canyon are the little Arkats (or R-Cats): OQ-19B drones that can fly at 300 m.p.h. at 20,000ft if the wind is right. Afterwards I saw the launching site of these efficient little target planes. With their 74 h.p. flat-four engines (built for 24 hours' life) making a satisfactory roar they are either catapulted from a JATO-powered ramp or take off from a trolley running on a circular track. The latter system is preferred, for JATO cans cost money, even in the U.S.A., and the range is run on a cost-accounting system.

Soon to be introduced as a drone is the RP-76, powered by a solid charge with twin nozzles. This will fly at 40,000 to 60,000ft at over 600 m.p.h. It will be launched from a mother aircraft—probably an F-89 Scorpion with one on each wing. Later it is planned to use a drone mother aircraft as a launching platform; this will be the RP-77, a turboprop machine with at least two hours' endurance.

While waiting for the rounds to be fired we struck out along a dirt road into the desert to see an old stage-coach hut, where horses used to be changed on the long haul through the desert from El Paso to Santa Fé. Built in 1870, its timbers were still sound, showing how well the clear and dry desert air preserves them. There was an old corral nearby, built 60 years ago and still standing.

"Ware rattlers," warned the sergeant leading us. We kept our eyes skinned, for in the camp we had seen a sizeable specimen caught only the previous day.

Back on the range, the New York citizens and ourselves saw a brace of Nike Ajax missiles fired; and down came the Arkats.

A very satisfactory day's work, spoiled only by the wait we had for the C-47 to come in and fetch us off the lonely strip. Said the captain: "Sure am sorry to have kept you. I had to orbit for twenty minutes because the range people wouldn't let me in. Some guy was firing a *mi*ssel!"

# AUTOMATIC FLIGHT

## *The Forty-Sixth Wilbur Wright Memorial Lecture*

THE evolution of automatic control of flight in the United Kingdom was the subject chosen by Dr. G. W. Gardner, C.B., C.B.E., B.Sc., D.Sc., F.R.Ae.S., Director of the Royal Aircraft Establishment, for his Wilbur Wright Memorial Lecture, due to be given before the Royal Aeronautical Society in London last night (May 15). Points from the historical section of the paper, *Automatic Flight—The British Story*, are given below.

The first British-proposed automatic flight control was suggested in 1891 by Sir Hiram Maxim, who intended to secure longitudinal stability by the automatic actuation of elevators in response to disturbances detected by a gyroscope. The earliest practical attempts to achieve automatic flight were stimulated by the prospect of using uninhabited aeroplanes as missiles and for other military purposes. The late A. M. Low and a small team worked on this problem during the first world war at Brooklands and at Feltham.

Experiments with an aeroplane designed at the Royal Aircraft Factory were made at Northolt in July 1917. Manœuvres were to be effected by full application of the otherwise fixed rudder and elevator in response to radio signals, and by throttle adjustment. This series of trials was unsuccessful.

In 1920 interest returned, and a programme was directed towards three projects: (1) an "ammunition carrier"—a gyroscopically controlled aircraft capable of flying on a steady course at a constant speed for a given distance; (2) an "aerial target"—an inherently stable aircraft with a 20-mile range; and (3) an "aerial torpedo"—to be dropped from aircraft and capable of flying under W/T control up to ten miles. This third project was abandoned after initial model-glider tests.

In October 1921 a landmark was reached when a manned Bristol Fighter, equipped with a simple gyro rudder control, was steered automatically in response to radio signals transmitted at ranges up to eight miles at Farnborough.

In mid-1922 attempts to launch and fly the pilotless target began at R.A.E. The earlier tests were made without radio control, prescribed manœuvres being planned in response to signals given by an engine-driven programme switch. The basis of the directional control, developed during these tests, was a free Whitehead torpedo-type gyroscope continuously spun.

Trials began in August 1922 from the carrier *Argus* and were continued by catapult launches from the destroyer *Stronghold*. Erratic flight behaviour was corrected by modifications to the gyroscope installation, and in June 1924 it was decided to replace the clockwork programming by radio control. Successful flights were made between September 1924 and February 1925.

In September 1925 work began on the development of an unmanned bombardment weapon with a range of 300 miles. The autopilot was based on the principles of the R.A.E. Pilot's Assister, and embodied monitoring of the automatic pilot by a magnetic compass. Radio control was to be omitted, the aircraft's predetermined course, height and range being maintained by compass and aneroid monitors of the autopilot, and an air log.

This aeroplane was designed *ab initio* as a pilotless machine. Its name, Larynx, was an abbreviation of "long-range gun with Lynx engine." To plot the aircraft's track, direction-finding observations were to be made on a transmitter carried in the aircraft. The interrupted C.W. transmission, indicating engine speed, aircraft speed and distance, may have been the first British application of radio telemetry from aircraft.

Referring to the first Larynx trials from H.M.S. *Stronghold*, Dr. Gardner said:—

"The first trial was planned to take place from Swansea Bay in the Bristol Channel to a point about 10 miles north of Cape Cornwall where a drifter was anchored to observe the end of the flight. The air log was arranged to cause titanium tetrachloride to be ejected at frequent intervals during the last five miles of the flight to facilitate observation from the drifter. Just before the launch, the engine was running at full throttle and some last-minute adjustments were being made by a junior member of the R.A.E. team. At this point, the trolley carrying the aircraft collapsed forwards and the aircraft crashed on the catapult. The propeller disintegrated, the container of titanium tetrachloride burst and the R.A.E. junior was projected by the tailplane over the edge of a 6ft high packing case head-first on to the steel deck. The destroyer was steaming into wind and much of the titanium tetrachloride smoke went down the ventilating shafts and found its way throughout the ship, depositing hydrochloric acid on the way. The R.A.E. junior was fortunate to survive to tell this story in a Wilbur Wright Lecture. . . ."

Subsequent launches and flights were successful, and five Larynx were sent for trials in Iraq during 1929. Although these trials were not conclusive, it is clear that, with a very small amount of development, this weapon could have been available to the Services in the early 1930s. The German V.1 of 1944 was based on the same control and navigation concept as the Larynx.

In October 1930 the R.A.E. was given the job of developing a target aircraft. The Fairey IIIF was selected, and the original Pilot's Assister principles were embodied in a new set of automatic equipment.

After preliminary flying (with a crew) during the autumn of 1931, the aircraft—known as the Fairey Queen—was taken to Lee-on-Solent in January 1932 and was fitted with floats. Flight trials from H.M.S. *Valiant* (photograph below, right) were made, and were followed by gunnery exercises in 1933.

It was decided not to put the Fairey Queen into production, but to develop quickly a less-ambitious target aircraft. A hybrid type was selected, which was virtually a Tiger Moth except for the wooden D.H.60 fuselage. The first attempt at pilotless flight was made from H.M.S. *Orion* almost a year after the inception of the project, and was a qualified success.

This aircraft, the Queen Bee, was the world's first realistic target aircraft to be used extensively. Altogether 420 were built. A Queen Bee base and five permanent Queen Bee units were established round the coasts of Britain (among improvements to the aircraft had been conversion to land operation) for Army exercises, while the Navy used Queen Bees in exercises abroad.

The Queen Wasp man-carrying aircraft was developed by Airspeed, but production was cancelled in the drive for more fighters. Later during the war, a Martinet was converted to pilotless operation (Queen Martinet) but did not go into production: still later a Spitfire was similarly converted.

The next real stimulus to the development of target aircraft came with the guided missile, and the production in Australia of the Jindivik. Engine, autopilot and radio gear were produced in the U.K. Fireflies and Meteors were developed for pilotless operation, and now take off when required from R.A.E. Llanbedr for engagement by missiles launched from Aberporth. Target Meteors are provided at Woomera. Canberras are also being developed by Short Bros. for use as target aircraft for missiles.

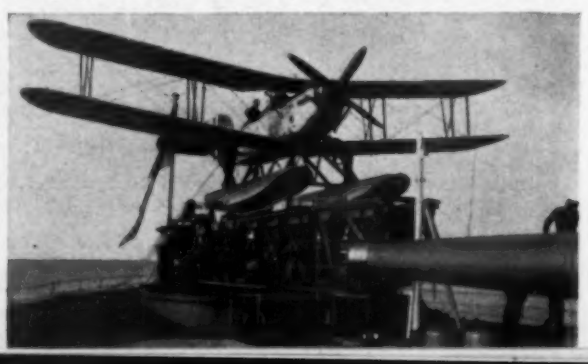
In the field of automatic approach and landing, Dr. Gardner referred to R.A.E. work on an I.L.S./magnetic leader-cable system:

"During the past three years aircraft attached to the Blind Landing Experimental Unit at R.A.E. have made over 450 landings under automatic control, 400 in a Varsity and 50 in a Canberra. In some landings, manual control of throttle was exercised but in all cases all flying controls were operated automatically; 125 of the 450 landings were made during February this year without any trouble or adjustments. These landings have been supported by over 1,150 touch-downs made with only partial automatic control, for example, control in one plane only or an automatic flare-out to a datum a few feet above the runway. Of these 1,150, eight hundred have been made in Varsity and 350 in a Canberra. The aircraft have suffered no damage in making these 1,600 partial, or completely, automatic landings. It is suggested that this is a most important and encouraging pioneering achievement."

Other sections of Dr. Gardner's paper were concerned with technical details of various autopilots; and modern problems of automatic flight in manned aircraft and in guided weapons. The lecturer concluded by relating the rôle of Government research establishments to the general scene of aeronautical development.

*Larynx pilotless aircraft (1927) mounted on H.M.S. "Stronghold."*

*Fairey Queen target aircraft (1932) mounted on H.M.S. "Valiant."*



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# Flying Aids

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678 Flight Instruments


**IN THIS review of flying aids we have assembled information on significant developments under the headings listed above. Some of these developments may change the face of commercial aviation, while others will further clarify some of its better-known features. They all to a greater or lesser extent affect the aspect of the cockpit instruments. One overriding process is at work in every department—integration. First, the various sub-systems in an aircraft are being integrated into a single, homogeneous system. Secondly, navigation and traffic control are becoming inseparable, because control depends on knowledge of position and intention and choice of track depends on traffic. Thirdly, navigation and flight-control functions are already being integrated in military aircraft and missiles and will inevitably eventually be so in airliners. The main significance of this review lies in describing most recent developments in these three fields.**

## NAVIGATION

### *Inertial Portents : Doppler Debut : Radio Aids Full House*

IN these days of electronic "you name it, we'll make it," the mention of navigation immediately conjures up a plethora of self-contained systems vaunted as the answer to every navigator's prayer. Of these the principal examples are inertial systems and Doppler radar. Yet the workaday aids such as Decca, Loran, Consol, Gee and the assortment of Vortac, V.O.R., ranges and N.D.B.s are still the basis of airline navigation. Decca is consolidating its ascendancy over its competitors by reason of its accuracy, flexibility and suitability for low- or high-level flight and for marine use.

The centre of the I.C.A.O. storm over the standard short-range aid seems to have shifted from the discussion of the relative merits of V.O.R. and Vortac to a growing struggle to oust both these in favour of an area-coverage system. With years of successful operational use in both fixed- and rotating-winged civil aircraft, as well as in a great variety of military applications, Decca Navigator lays a strong claim to adoption as a new standard. Its long-range equivalent, Dectra, is now in being on the North Atlantic and trials in R.A.F. and PanAm aircraft have given most encouraging results. The Decca companies are also offering a fully integrated system called D.I.A.N., which presents on a single pictorial indicator Decca, Dectra and Doppler information. This combined system is probably more advanced and offers greater scope for development than any other.

But the Decca lead in the long-range field is by no means unchallenged; and three American systems and one French are in hot pursuit, politically if not technically. They are Cytac (Sperry), Omega, Navarho and Radio Mailles (radio web). All were discussed internationally in Montreal last year (I.C.A.O. 6th Communications Division) but no decision has been made on which of them will become the world-wide standard.

Navarho is, essentially, a long-range rho-theta aid designed to operate in the 90-110 kc/s band: by "rho-theta" in this context is meant that distance and bearing are derived from a single ground installation.

The azimuthal (theta) information is obtained by sequential transmissions from two of three aerials located at the corners of an equilateral triangle whose sides are approximately 1,200 metres long. These transmissions are phase- and amplitude-synchronized and, in the aircraft, the amplitude signals are gated and bearing information derived by vector summation.

Distance (rho) is obtained by phase comparison of two signals, one generated by the ground transmitter and the other by equipment in the aircraft. On the assumption that the phase stability of these two signals is of a very high order, any phase variations which occur are caused by a change in distance between the user and the transmitter. However, the airborne stability required to provide acceptable accuracy is of the order of one part in $10^9$ for twelve hours.

The ranges obtained in a U.S. evaluation of Navarho varied from 1,100 n.m. overland by day to 2,000 n.m. over sea by night, with distance accuracies of $\pm 9$ n.m. (day) to $\pm 35$ n.m. (night) and azimuthal accuracies of $\pm 3.8$ to 4.4 deg (all 95 per cent probability) in the same conditions.

Although the U.S. have, in the past, pressed the claims of Navarho with some emphasis, it is apparent that their interest in this system is now declining and, it is understood, their trial station is now on a care and maintenance basis. [*Contd. overleaf*

## NAVIGATION . .

Like its forerunner, standard Loran, Loran-C is a pulse hyperbolic system consisting of a master and two or three slaves; Loran-C, however, operates in the 90-110 kc/s band. Master and slave transmissions are synchronized so that the time difference between the receipt of master and slave pulse groups can be plotted as hyperbolæ. The major difference between Loran-C and standard Loran, apart from the frequencies used, is that these time-difference measurements are made by utilizing both the pulse envelope and the phase of the carrier within the envelope.

Loran-C uses at least the entire available band-space for long-range aids, i.e., the 20 kc/s between 90 and 110 kc/s. Very high power is required to achieve the ranges estimated—about 2,000 n.m. over sea and 1,200 n.m. over land—and experimental stations have radiated 60 Kw. Even higher powers—up to one megawatt—have been postulated for operational installations.

The claimed accuracies of the system are high. Fixed monitor stations in the U.S. report average night and day errors of ±150ft at 400 n.m. to ±1,000ft at 1,400 n.m., using ground wave propagation. No information on airborne evaluation results are available as yet.

The third U.S. system is Omega. This is alleged to be a development of Radux but is almost identical to the British Delrac System, the announcement of which preceded it by some four years.

Omega uses frequencies in the 10-14 kc/s or V.L.F. band, and is a C.W. phase-comparison hyperbolic system. From three to six synchronized stations each operate on a basic and secondary frequency differing by 500 c/s. Transmissions are made sequentially in a fixed schedule and position lines are obtained by determining the phase-differences in the arrival of the basic frequency from any two of the stations: the secondary frequency is similarly compared to give ambiguity resolution.

The range of the system is assessed at 5,000-6,000 miles with a predicted accuracy of one mile, on a 95 per cent probability basis within the coverage. To obtain these ranges it would appear that very high powers (100 kW), and correspondingly complex antennas would be required. Full-scale trials of Omega are not expected before 1960.

Omega, as stated above, is similar in concept to Delrac, which was first announced about four years ago. In Delrac a series of master/slave combinations, also operating in the V.L.F. band, on a 1,000-mile base line, transmit phase-related signals on a time-frequency-multiplex basis to provide position-line information. Fixes are obtained by using position-lines from any two pairs and relating them to an overprinted lattice or by displaying them pictorially on the Decca Flight Log.

The ranges predicted for Delrac are of the order of 3,000 miles with positional accuracy not worse than ±10 n.m. within coverage. Since both Delrac and Omega are C.W. phase comparison aids, the difference in both range and, particularly, accuracy claimed by their proponents are quite striking. Of the two, it would seem that the more conservative Delrac claims are those most probably attainable at these frequencies by such techniques.

The major difference between the two systems is that, whereas Omega seeks to resolve ambiguity in one "coarse" step, Delrac plays safer and does it in three or more, by using additional frequencies.

Although Delrac has not yet been evaluated, many of the techniques involved have been used and proved in other systems.

Of the long-range systems considered here Dectra is furthest ahead in evaluation; a trial ground installation has been in operation over the North Atlantic for the past twelve months.

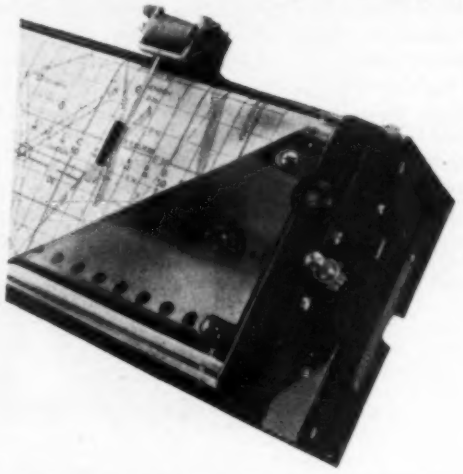
Dectra, which operates on approximately 70 kc/s, consists of a master/slave pair positioned at one end of a given route on a base line approximately 60 to 100 miles long. Phase comparison techniques lay down a hyperbolic pattern between these stations which extends over the required route and forms the tracking lattice. A further slave is located at the end remote from the tracking pair and similar techniques between it and the remote master provide the ranging pattern across the track. The trial installation now operating has master and slave located in Newfoundland, with the ranging slave near Stirling in Scotland.

The initial evaluation of Dectra was done in an M.o.S. Valiant which has so far established tracking accuracies of the order of ±2 n.m. standard deviation at ranges of up to 1,500 n.m. Whilst ranging errors have not yet been fully assessed it seems probable that approximately the same order of accuracy is being obtained.

The significance of these results is, of course, that they provide a means of reducing the separation standards on the North Atlantic and, for that matter, on any similar route where traffic congestion is building up. As is well known, operators on the North Atlantic are often penalized by separations of 120 n.m. lateral and 30 min longitudinal between aircraft on the same altitude, which frequently force them to accept altitudes below the optimum or to endure considerable delay.

It is for this reason that a number of civil airlines are now evaluating Dectra themselves. These include B.O.A.C., PanAm, S.A.S., Swissair and T.C.A., with others—amongst them El Al—extremely interested.

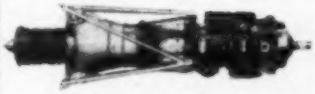
*The Decca Navigator, with Flight Log pictorial presentation (shown in detail below) is suitable for fixed- or rotating-wing aircraft. Above, it is in a U.S. Army H-34 helicopter in Germany.*



The airborne installation includes both Dectra and Decca. Presentation is made on the Flight Log. Dectra is set up accurately from a Decca reference and thereafter the aircraft track is recorded continuously throughout the trip. The position of the aircraft is immediately known, at any time, by the location of the pen: together with the appropriate Dectra lattice the chart is overprinted with a latitude/longitude grid and carries distance to go/distance gone information plus headings to diversions. Position reporting is thereby greatly simplified as is the detection of wind changes and the calculation of ground speed and E.T.A.s.

As already reported in *Flight*, the Decca Company are proposing to combine Doppler with their Decca/Dectra in what they term the D.I.A.N. (Decca Integrated Air Navigation) System. The reasoning behind this D.I.A.N. concept is that such an integration will enable D.I.A.N.-equipped aircraft to fly accurately in a complex traffic area using Decca/Dectra whilst, at the same time, checking and removing Doppler errors—particularly those arising from the compass—by reference to these more accurate systems. In the event of Doppler alone being required it can therefore be used from a datum of high accuracy.

Perhaps more important is the fact that Doppler information will also be presented pictorially on the Flight Log. This will not only save cockpit instrumentation space and weight but will also enable complex computation—the provision of latitude/longitude or rho/theta information and compensation for compass variation and convergence, for example—to be provided on the charts



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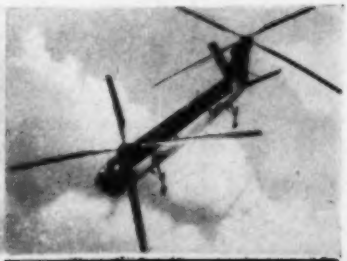

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**NAVIGATION . . .**

in advance, rather than by additional boxes in the aircraft. Further, if the aircraft is to operate in any area where Decca/Dectra are not available, Doppler can be used in the pictorial form and thus no mental re-orientation is required of the pilot.

The basis of the French Radio Mailles (also known as Radio Mesh and Radio Web) is that, if two separate stations transmit signals modulated by adjacent but distinct frequencies the signals are received in phase along a moving interference pattern, or equi-phase line, hyperbolic in shape. The speed is governed by the choice of signal frequencies, and the distance between two stations is therefore scanned at a pre-determined rate.

The aircraft equipment consists essentially of a counting device measuring the time interval between the passage of two equi-phase lines from which position lines are derived. In a further variation of this system the appropriate air traffic control receives a position signal from the aircraft when an equi-phase line passes through it.

In Radio Mailles the stations are normally located at the corners of a square and, although it was initially planned as a short range system, the possibilities of choosing suitable frequencies, increasing the sides of the square and thus converting the system for long range application, are being considered. Radio Mailles is in a purely experimental stage and no test results are so far available.

Doppler radar, finally shorn of the last shreds of security cover, is now preparing to make its début in civil service. Already one adapted system has flown in scheduled service with PanAm; and the first genuine civil Doppler is being demonstrated in a Viking. Companies engaged in preparing civil equipment include British and Canadian Marconi, Decca Radar, Computing Devices of Canada, General Precision Laboratories, Collins, Bendix and Radio Corporation of America. The last three companies have only recently entered the field.

Considerable experience of Doppler radar in operational service has now been gained; and probably more in Britain than in America. Some of the results of R.A.F. experience were detailed during a meeting of the Institute of Navigation last November (*Flight* for November 29). Further details on the use of the Marconi AD.2000 were given in a paper presented in March to the Institution of Electrical Engineers convention on radio aids to aeronautical and marine navigation (*Flight* for April 11).

These military systems have formed the basis for the design of highly specialized Doppler navigators for civil airliners and the following remarks from Decca Radar, Ltd., show the reasoning which led that company to the design of the Doppler element of D.I.A.N. It appears to bear a fairly close relationship to a very compact Decca military Doppler displayed at R.R.E. Malvern late last month.

Doppler information may be derived by a variety of types of transmitter/receiver, and at this stage in the evolution of Doppler it is not possible to state categorically that one technique is better than another. Inevitably the technique which is selected represents that compromise which the particular designer considers will best meet the end he has in view.

Several factors influence the type of system used, the two main types being coherent systems and self-coherent pulse systems. The first type may be further sub-divided into the pure continuous wave systems, frequency modulated continuous wave systems, and coherent pulse systems.

Each of these has both advantages and disadvantages, the salient features of each being as follows:—

*Continuous Wave.* Unmodulated continuous wave seems at first sight to offer a simple straightforward system. But this proves to be a false assumption since very great frequency stability is required, and reflections from the radome and other structure which may be vibrating cause unwanted frequency modulation of the transmitter which, unless transmitter-to-receiver isolation is of a very high order, cause spurious signals and extra noise in the Doppler band. This forces the use of separate transmitting and receiving aerials, and so is wasteful of space in the aircraft. It also makes it almost impossible to use an aerial which swings in azimuth for drift measurement.

*Frequency Modulation.* One way of overcoming some of the difficulties associated with continuous wave systems, is to adopt frequency modulation of the transmitter. When this scheme is used, the Doppler frequency is obtained by mixing the returned signal with a sample of the transmitted signal. This mixing produces a signal at modulation frequency, and harmonics of this frequency with the Doppler frequency as sidebands to these frequencies. One property of this scheme is that there is zero signal returned from zero range thus removing difficulties caused by zero-range reflections; and improved discrimination against such effects can be obtained by using a harmonic of the modulation frequency. The modulation index is adjusted to give the maximum power at the required harmonic.

There is, however, some price to be paid for freedom from trouble. For example, using the 3rd harmonic introduces a loss of 13 db compared with a C.W. system. The Doppler frequency from each aerial beam can be obtained with a good signal-to-noise ratio by using coherent detection. Unfortunately these frequency spectra become very broad at high altitude due to unwanted F.M. of the transmitter; and this has to be cancelled out by mixing the spectra from forward- and backward-looking beams before tracking. This procedure causes the generation of extra noise and so most of the advantage of coherent detection is lost.

*The amused look of Minneapolis-Honeywell designer Philip LaHue belies the intensive work which went into the design and production of the floated inertial-quality gyro, which he is here comparing with a child's toy.*

*Coherent Pulse.* The coherent pulse system may be thought of as a sampled C.W. system, the zero-range reflections being removed by the receiver gating. The previous remarks about coherent detection and mixing before tracking apply. Principal disadvantages originate in the need for close frequency control and the difficulties associated with obtaining coherent pulses of microwave energy. A further difficulty is "altitude hole" effect by which, at heights which correspond to the echo return time, the return signal is received while the receiver is gated for transmission and a reduced signal of lowered accuracy is obtained. But this can easily be overcome by frequency modulation of the P.R.F. at a low frequency.

*Self-coherent Pulse.* A self-coherent system has the merit that there is no stringency in respect of transmitter control. The Doppler frequency is obtained by using the energy returned from one beam as the reference for that returned from another, so that a continuously operating reference oscillator is not needed provided there is time-coincidence between the returns from the two beams. Neither is there any trouble from transmitter noise because the receiver is gated off during transmission. But there are "altitude hole" difficulties.

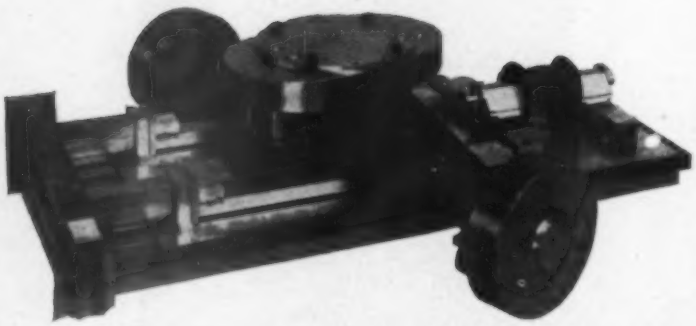
The coherent systems mentioned here all have the advantage that no microwave local oscillator is needed for the receiver, but all require carefully regulated power supplies for the transmitting tube, which is normally a klystron. Furthermore, the transmitting tube has an efficiency of only about 3 per cent so D.C. power requirements per transmitted Watt are high.

The question of comparing the realizable efficiency of the four systems is quite complicated, but to a first approximation the C.W. is the most efficient, the coherent pulse probably next in order, and the frequency modulated and self-coherent roughly similar at perhaps 15 db below the C.W. performance.

This comparison refers to the efficiency with which Doppler power is obtained from transmitted power, but when the comparison is made to include the efficiency of the transmitting valve, the self-coherent system is substantially the more efficient because the transmitter valve, being a magnetron, has an efficiency of between 20 and 30 per cent, whereas in the coherent systems the transmitting valve is a klystron with an efficiency of about 3 per cent. Furthermore, if it is necessary for any reason to increase performance, this can be done with a self-coherent system simply by increasing transmitter power. If the same must be done with a C.W. system, or an F.M. C.W. system, it is necessary not only to increase the transmitted power but also to increase the degree of isolation between transmitting and receiving aerials. If it is hoped to use a duplex system, the degree of performance to be expected from a C.W. system may be limited by the performance of the duplexer.

In the case of the self-coherent system, duplexer operation would certainly be used, which offers the practical advantage that crystals may be located in the T.R. unit remote from the aerial. In the case of C.W. and F.M. C.W. systems, either a duplexer with limited operational capabilities can be used with crystals mounted in the T.R. system, or separate aerials can be used in which case either the crystals may be mounted on the aerial or a second waveguide must be installed.

When all the factors above-mentioned had been taken into con-



*The very compact aerial of the Doppler element of Decca D.I.A.N.*

**NAVIGATION . . .**

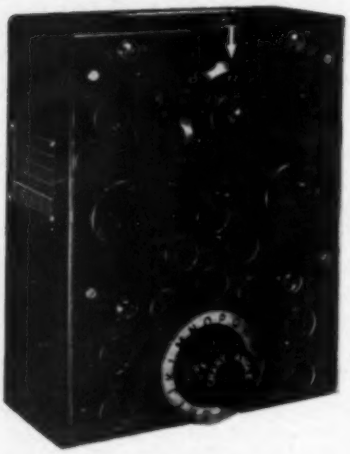
sideration, very little doubt was felt that the most straightforward system with the most attractive installation and maintenance characteristics would be obtained by the use of the self-coherent system. For certain more limited applications, such as low-altitude, low-speed aircraft, it is conceivable that a C.W. type of system might show some advantage.

D.I.A.N. was first described in detail in *Flight* for August 23 last year. The Doppler element works in the X-band at about 8,900 Mc/s. It uses a long-pulse system with a pulse duration of 3 microseconds, and a repetition frequency of 45 kc/s. During pulse transmission the receiver section is inhibited. To avoid "altitude hole" effect the repetition frequency is swept between 40 and 50 kc/s at a frequency of about 50 c/s. The power input required is about 300W and peak transmission power is about 20W. The highest voltages are about 950V. The aerial, transmitter/receiver, tracker/computer and indicator are unpressurized, can operate at heights up to 60,000ft and together weigh about 80 lb. The aerial requires a skin cutout measuring about 30in × 12in; and pitch stabilization up to ±20 deg is effected, using signals from a remote gyro if necessary.

The Decca Doppler senses the frequencies from the two pairs of aerial beams independently by phonic-wheel discriminaters and, by comparing them, derives the components of groundspeed across heading and along heading. The aerial is therefore not rotated to sense drift by its mechanical displacement; and Decca claim that where the ultimate outputs are required in the form of rectangular co-ordinates such as grid co-ordinates, latitude and longitude, or co-ordinates operating a Flight Log this procedure offers more direct methods of computation and is therefore likely to be more accurate. Shaft rotations proportional to the two Doppler frequencies are converted into A.C. analogue voltages by means of precision tacho-generators, offering a very flexible means of computation for the outputs required from this system. Wind speed and wind direction or, alternatively, groundspeed and track, can be selected by switching on the same dial. The various types of co-ordinates can be presented on additional equipment.

Since wind speed and direction are automatically calculated and stored, the Decca Doppler continues to compute track according to a wind measurement after loss of signal rather than according to the last measured drift value. Provided the wind does not alter, computation thus remains accurate regardless of changes in aircraft heading. An input of true airspeed and heading is required, the former being manually inserted if desired. Any inaccuracy in true airspeed input will not affect the tracking accuracy of the system. The problem of compass accuracy and magnetic variation setting is easily overcome by arranging for the variation quantity to be included in the chart orientation angle of the Flight Log. A "land/sea" switch is incorporated. Dectra, Decca and Doppler signals are all presented on the Flight Log and, while Dectra or Decca is being used, Doppler signals remain available on the co-ordinate dials. Decca are now working on a computer which could convert Navigator hyperbolic co-ordinates into rectangular co-ordinates so that a common chart could be used for the two systems. The complete D.I.A.N. is expected to weigh about 170 lb and trials in a PanAm DC-7C may start in August.

Now being evaluated in a Viking (a report will appear in an early issue of *Flight*) is the Marconi AD.2300 Doppler Navigator. Marconi have had four years of experience with the AD.2000 equipment in R.A.F. service; and the results were detailed in a Doppler symposium reported in *Flight* for November 29 last year. The AD.2300 is a completely new and specialized civil system, first details of which were reported in *Flight* for June 21 last year. Various alternative computers are arranged to provide combinations of the following outputs: continuous and immediate latitude and longitude position; distance to go along a leg of a predetermined flight plan; distance to go along a composite desired track to reach a destination; wind direction; wind speed; groundspeed and drift angle; deviation-indicator for steering along a desired rhumb line or great circle track; distance to destination together with a visual indication of reaching the end of a particular leg; steering signals to an autopilot or flight system; automatic correction for magnetic variation. Changes of destination or turning points may be introduced at any time.



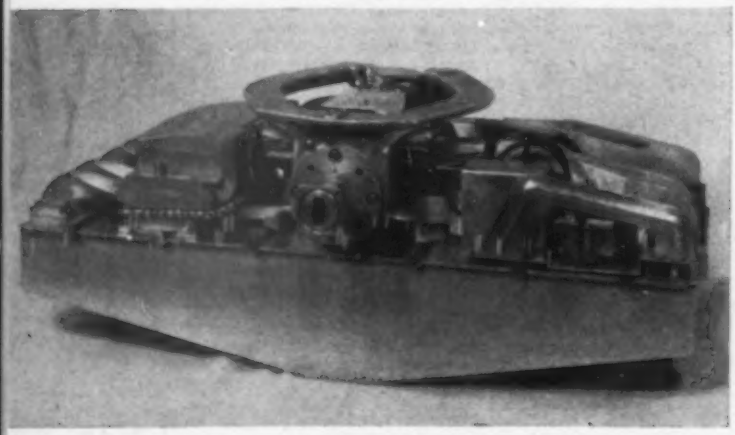
*D.I.A.N. combined control panel for Decca, Dectra and Doppler.*

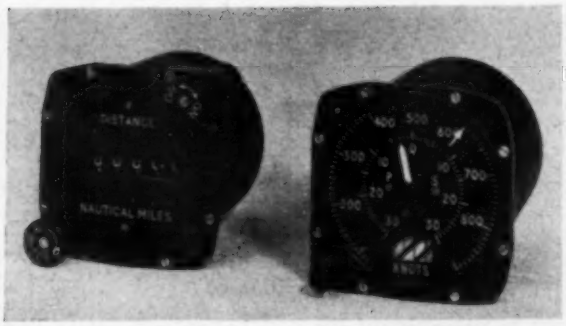
The memory system continues computation after loss of signal, using last known groundspeed and drift angle. In this event, corrections to groundspeed and drift angle may be manually inserted to allow for wind changes. When Doppler signals are restored, the equipment automatically locks-on to the signal and resumes normal working.

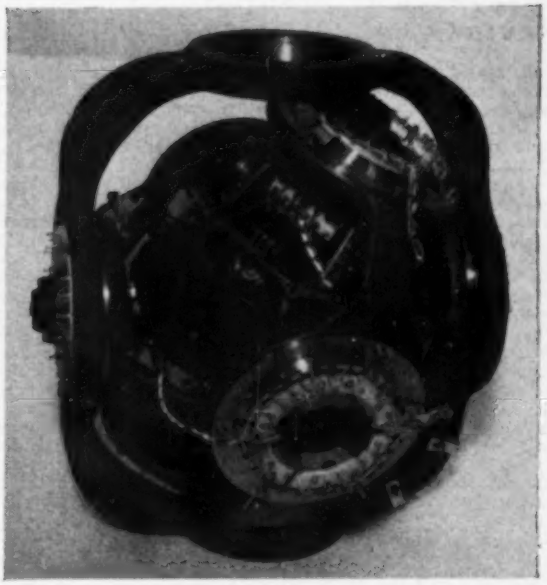
AD.2300 uses a C.W. system with an electro-mechanical tracker requiring no calibration and failing safe. Rack-mounted units are designed to ARINC standards and all valves have American equivalents. The complete equipment, including aerial and computer, weighs 130 lb. Height, speed and drift angle limits are respectively 50ft to 50,000ft, 80 to 900 kts and ±45 deg. The AD.2300 aerial can accept pitch and bank angles up to 10 deg and 20 deg without loss of accuracy and contains two slotted waveguides for transmission and two for reception. The fore-and-aft pair of beams alternates from side to side, controlled by a mechanical waveguide switch. Beam width at half power is 3½ deg. An unpressurized case, with standard ARINC cooling, houses the transmitter/receiver, the carrier-wave being klystron-generated. Groundspeed is measured by a phonic-wheel discriminater and the aerial is rotated to show the drift angle. Compass heading and true airspeed inputs and a number of outputs are represented by synchro-shaft positions and an essential part of the computation is performed by mechanical ball resolvers operating on the shaft positions.

AD.2300 will provide latitude and longitude position at latitudes up to ±80 deg, though the basic speed and drift signals obviously

*Aerial of Marconi AD.2300 Doppler navigator. It is pitch-stabilized and swivels to measure drift angles up to a maximum of 45 deg.*





***Above, the distance-gone and drift-and-groundspeed dials of the Marconi AD.2300. Right, the Minneapolis-Honeywell Miniature Stable Platform using three floated, miniature gyros.***

continue everywhere. A run/fix facility in the computer allows the indicators to be stopped for manual setting without loss of computation.

American companies are making considerable efforts to introduce civil Doppler equipment. A General Precision Laboratories Radan PC-201A made at least eighteen crossings of the North Atlantic in a PanAm DC-7C. The particular Radan was specially prepared for the trials and comprised an aerial and transmitter/receiver in one 35-lb unit; the frequency tracker weighing 48 lb; and a control panel and groundspeed and drift indicator. Total installed weight was 125 lb. Power input was approximately 500VA at 110V, 400 c/s and 2A from 27.5V D.C. The A.R.T. and frequency tracker required 5.3 lb/min and 2 lb/min of cooling airflow, respectively.

A low-power, high duty-cycle magnetron in the transmitter generated pulses at 8,800 ±30 Mc/s with an average power output of 10W. Both pulse width and pulse repetition frequency were varied continuously in unison to maintain constant duty ratio of 25 per cent, holding a constant level of average power designed to reduce "altitude-hole" effect.

The A.R.T. was installed in the starboard wing fillet behind a cutout of 2ft 6in × 1ft 8in, the aerial being pitch-stabilized using level-sensing switches. Two beams alternated by a wave-guide switch from right forward and left aft to left forward and right aft at 1 c/s, depression and lateral deflection being respectively 68 deg and 28.5 deg. Beam width was 4 deg.

The switching action caused the frequency difference between simultaneously received echoes to shift up and down when the aerial was not aligned with aircraft track. Magnitude direction of this periodic frequency shift was sensed and the aerial rotated until it was aligned with track. Deviation between aerial axis and aircraft axis was equal to drift.

Radan can operate over a speed range from 70 to 1,000 kt and at heights between 200ft and about 70,000ft. Groundspeed and drift angle were displayed on a single dial, a veeder-counter showing distance gone. Information presented was delayed for one or two seconds to allow averaging so that apparently erratic indications should be avoided.

Radan was in the DC-7C for three months and provided drift and groundspeed indications accurate enough for long-range navigation—and in some cases more accurate than those derived by the methods used for checking the system. Continuity of operation was good, although some interruptions were caused by such factors as poor terrain reflectivity and excessive aircraft attitude displacements. The "distance gone" counter suffered some unserviceability.

Radan was also coupled to the autopilot. This and the distance gone measurement "proved to be of inestimable operational value" and PanAm consider them to be essential to a complete Doppler system. In addition, PanAm want continuous automatic alignment of the drift and groundspeed indicator; an adequate memory system to preserve Radan information during aircraft manœuvres and periods of poor signal return; and a meter to show the relative strength of the echo as a monitor of satisfactory operation.

PanAm found that signals were lost in all banks exceeding 7 to 8 deg at 30,000ft, although 30 deg banks at 1,000ft were almost invariably tolerated. The poorest reflecting surfaces found were sea conditions Beaufort 0 to 1 such as existed in the centre of surface anticyclones. Rugged mountainous terrain also gave poor returns, although snow-cover may have caused this. It seemed that a sea state slightly below the point of white cap formation represented the lower limit of acceptable reflectivity, as did also

***The "clean area" where special gyros are assembled by the Guided Weapons Division of the English Electric Company at Stevenage.***

## NAVIGATION . .

land fraught with still lakes, snow or ice. The best reflecting surface was rough sea (Beaufort 4 or above). Reasonably level dry land was satisfactory but had not the constancy of rough water.

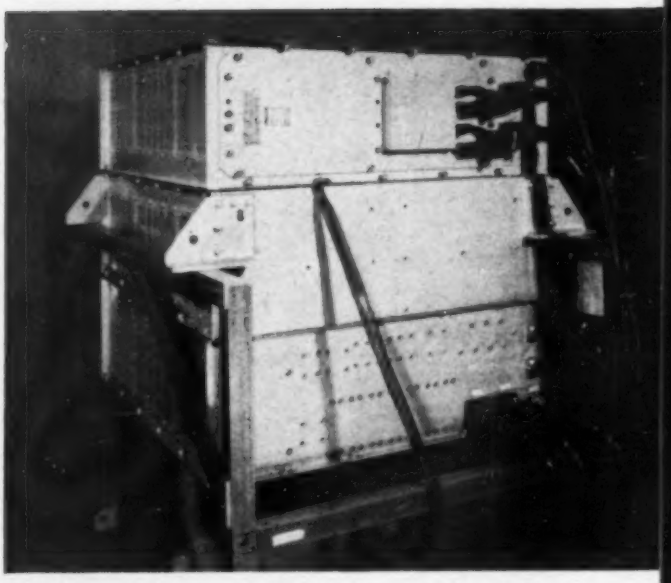
On a few occasions the signal was lost in extremely heavy precipitation associated with passage through frontal cloud formations of cu-nim type. Such interruptions were very short.

As reported in *Flight* for April 12 last year, the Canadian Marconi Company produced a Doppler radar called DAGMAR (drift and groundspeed measuring airborne radar) for military aircraft. A civil Doppler, designated CMA-621, has now been developed. The aerial is pitch-stabilized, rotates to measure drift angle and transmissions are in the X-band. Drift angle and groundspeed are indicated on a 3in dial. CMA-621 is at least partly transistorized and transmitter/receiver and tracker are enclosed in one unit. Operating heights are from 50 to 50,000ft; drift angle range is ±30 deg; speed indications from 90 to 900 kt; pitch-stabilization range, ±20 deg; and roll range, without stabilization, ±15 deg.

Computing Devices of Canada, Ltd., have announced a Doppler navigation computer called Skyline which is designed to operate with any Doppler radar. Being fully transistorized, the indicator and computer weigh respectively 6.5 lb and 7.3 lb, the single dial showing miles gone and miles left or right of track on veeder counters. Magnetic course and desired deviations from it are set on peripheral scales. Additional features can be added.

About eight years have elapsed now since the first inertial navigation system, made by Sperry and using air-bearing gyros, was first successfully flown in a DC-3. The basic principles of inertial navigation have been clearly appreciated for much longer than this; and tremendous effort, both in terms of design work and financial outlay, have been devoted mainly to developing components of the extreme accuracy required as well as to deciding on a number of compromises—the so-called hybrid systems. It is probably true to say that a pure inertial system cannot yet be made to continue accurate position indications for longer than about an hour. Practically every bombardment missile now contemplated relies on some type of inertial system for guidance.

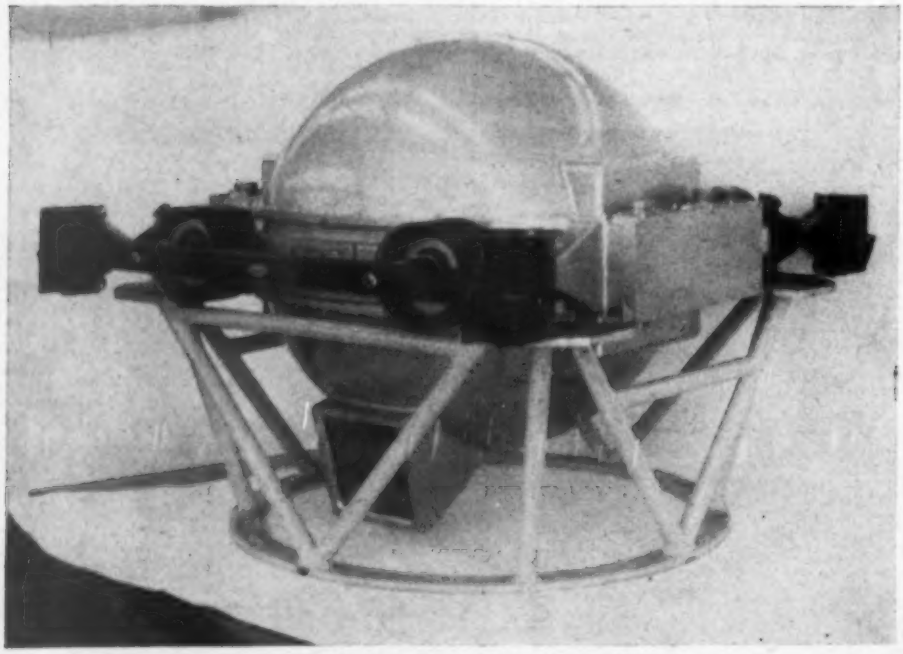
Newton's second law states that force is equal to time rate of change of linear momentum. In order to mechanize this law and derive positional information, a self-contained inertial system requires two or three accelerometers, a gyroscopically stabilized platform, a time-piece, a computer and associated electronics and power supplies. Each of these components, and particularly the gyros, have to be made to dimensional and material tolerances never before attempted on a production line. Special buildings have been erected for this purpose, all sections of which are isolated, fully air-conditioned and temperature controlled, dust-free, and protected from even faint vibration. Yet, although the gyros which emerge from such factories require power supplies stabilized to plus or minus a fraction of a volt and temperature control to better than ±1 deg C for operation, many of them are capable of withstanding a missile launching.



*The computer of the pure-inertial guidance system for the Titan ICBM. It combines accelerometer and stored information to control the weapon trajectory. Bosch-Arma is the prime contractor.*

An inertial navigation system is extremely costly; it has stringent requirements with regard to stability of power supply and temperature control; it is not yet capable of providing accurate information over the length of time for which airliners regularly remain airborne. In addition, many of the gyros used require anything up to three or four hours to warm up, erect and align before they can be used. These conditions, if nothing else, seem to preclude the application of pure inertial systems to civil operations during the next few years. But certain inertial components, particularly the gyros, will almost certainly find civil application in the relatively near future, although it should be borne in mind that the peculiar operating and warm-up conditions may make them awkward.

One of the factors limiting the accuracy of Doppler radar is the *relative* inaccuracy of present compass systems. Here the use of inertial-quality gyros might provide a very real improvement; and this might be extended by producing a master gyro reference based on several inertial-quality gyros. Such a development has been hinted at by S. G. Brown, Ltd., who already have their



*"Stable table" is the irreverent nickname for the gyro-stabilized platform which holds the accelerometers for the Titan ICBM pure-inertial guidance system.*

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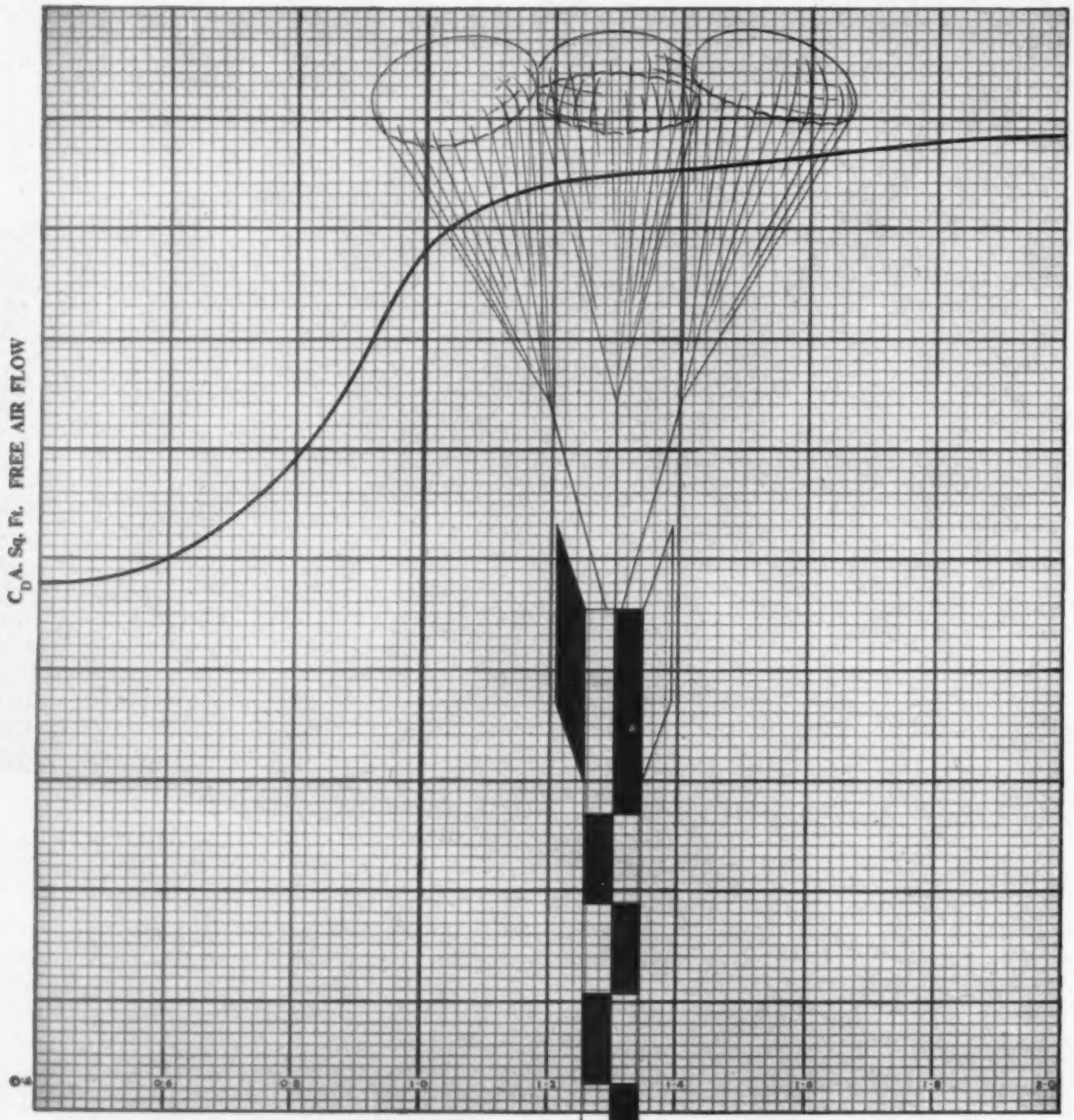


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**NAVIGATION . . .**

M.R.G. in production. Now, from Minneapolis-Honeywell, comes news of the Miniature Stable Platform, a four gimbal, all-attitude gyro reference intended for use as "a central gyro reference system and as a short-term inertial system." The basic components of the platform are the Honeywell GG49 Miniature Integrated Gyro and the GG56 Miniature Pendulous Accelerometer. Both these units are fully floated and represent a significant advance in miniaturization. The GG49 is capable of the performance of the HIG-6 floated gyro but has only 1/10 the volume and weight.

The Miniature Stable Platform has one unit containing the gimbal structure and gyros, and another holding most of the electronic equipment necessary to operate the Platform. In this way, the cooling requirements are lower and mounting and accessibility are made easier. Each circuit in the amplifier section is separately packed in a hermetically sealed can with solder-type headers. Silicon transistors and printed circuits are used.

The innermost gimbal of the platform holds three gyros, three accelerometers, three accelerometer pre-amplifiers and temperature-control circuitry in a total volume of about 40 cu in. Instead of heating each component individually, the gimbal itself is temperature controlled through a bridge-circuit sensing system and cartridge-type heaters embedded in the casting. Temperature is maintained within ±0.5 deg F. Resistance heaters are embodied elsewhere to provide fast warm-up—8 min from −65 deg F.

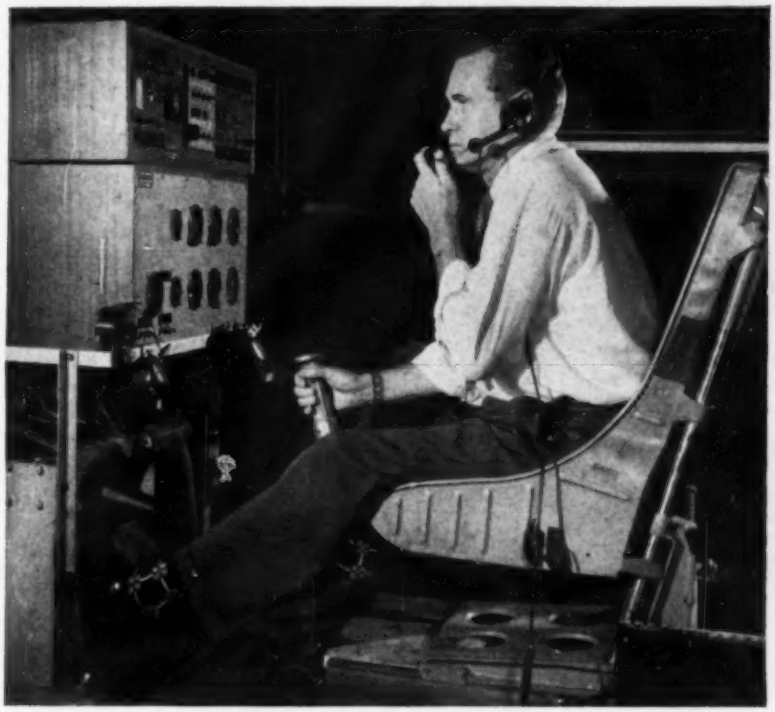
Pancake synchro-transmitters and Pancake D.C. servo motors are located at opposite ends of the heading, inner roll, elevation and outer roll gimbals, being made integrally with pivot bearings. Problems associated with gearing and alignment are thus greatly relieved. The synchro-transmitters have a maximum error of ±6 min of arc. A three-axis repeater is used as a platform attitude output system, and, in this way, 30 different outputs have been supplied in one particular application. Geometric decoupling of elevation and roll gyros and of inner- and outer-roll gimbals are accounted for. A small and simple static device has been developed to obviate the need for a precision source of frequency to drive the gyro wheels. The bias windings are supplied with a reference current which varies as a linear function of frequency and which is independent of line voltage. A high degree of accuracy is thus maintained even though the aircraft power supply frequency may vary over a wide range.

A stable platform of this kind is far removed from the large and complex computer and platform of a pure inertial system, but it might serve a relatively compact stellar-inertial hybrid where the star-tracker could locate the platform vertically and the platform vertical could in its turn be used to align the star tracker.

It will probably be some time before the airlines are prepared to involve themselves in the operational problems of inertial quality equipment. C.M.L.

# FLIGHT CONTROL SYSTEMS

## *Integration Unlimited*



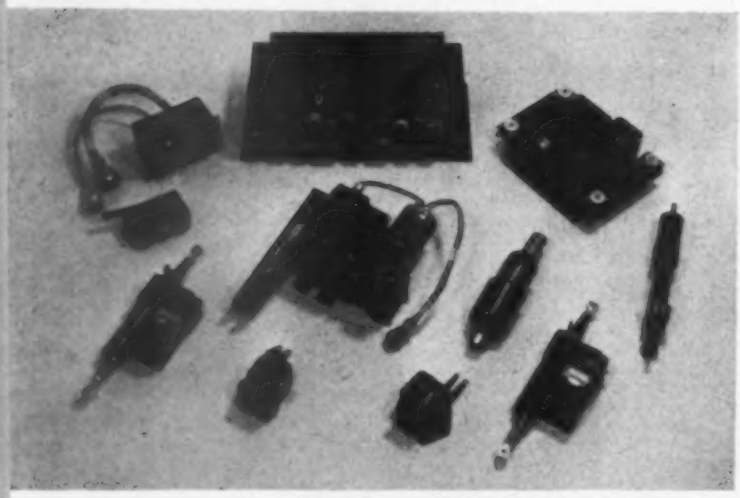
*A Bendix engineer operating the mockup of the B-58 ratio-changing flight control system.*

IT will be a long time before a control system as compact and as flexible as a human pilot will be developed; and success in such a venture will be based upon accurate artificial reproduction of man's special ability to remember, to reason and to decide. The usefulness of the system, when once it is produced, will also depend greatly upon its size and complexity and upon its reliability. Considerable work has been done in scientific laboratories on memory and learning systems which can go further towards imitating a man's mind than was previously thought possible, but there is much which can still not be reproduced in reasonable "hardware." The main hurdle as far as aircraft control systems are concerned is to introduce a suitable probabilistic system to deal with information from a number of relatively uncertain sources of information.

Where control of an aircraft depends directly on the interpretation and integration of information from a number of well-known and reliable sources automatic processes can give accurate and efficient results. Far-reaching progress in sensing devices and computers and in miniaturization and reliability have already made automatic control capable of achieving integration of more varied phases of flight. These are the more attractive, especially since in many cases the human pilot is too busy or too slow or insufficiently perceptive to recognize certain factors which might radically affect the accuracy of his work or his safety.

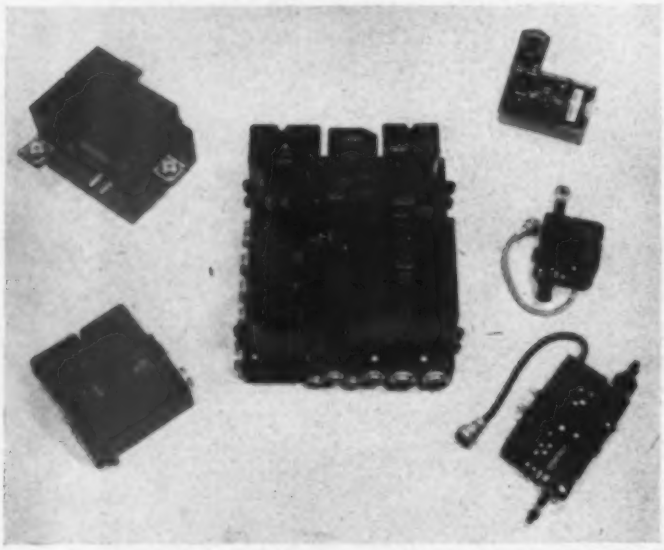
Military flight control systems have now reached the stage where they can be arranged to perform a complete, clearly-defined operational task accurately and economically. The task may involve a long flight to a given point and the delivery there of a bomb or missile; or it might be simply the solution of the complex velocity and ballistic factors involved in intercepting and firing at an enemy aircraft whose position and vector have been established by a tactical radar. In both cases information from navigational aids or data link signals is received in the aircraft and translated by computer into control demands. They can be passed to the autopilot which, according to the particular characteristics and requirements of the aircraft, moves the control surfaces and other services to produce the desired flight path and weapon release.

Some years ago, and not without a considerable struggle, the U.S.A.F. put into service a fire-control system for intercepters



*Above, the Louis Newmark helicopter autopilot for autostabilization, cruise and hovering control. Below, the fighter autopilot, by the same company, possibly designed for the Sea Vixen.*

## FLIGHT CONTROL SYSTEMS . . .



*A Sikorsky S-55, below, hovering close to the ground controlled by a Sperry autopilot. Both pilots have their hands off the controls.*

which automatically sought and locked-on to a target, manœuvred the aircraft, trained unguided rockets and fired them at the right moment without the intervention of the pilot except in choosing the correct target. Tracking, computing, aiming and firing were all part of a single integrated automatic system over which the pilot sat as arbiter and monitor. His main task was to take off and climb into the vicinity of the target under G.C.I. control. After that he engaged the autopilot and supervized locking-on of the radar. Later, the same autopilot was able to execute a coupled I.L.S. approach and the fire-control radar could be used to scan the terrain below and to identify radar beacons. The actual firing pass could be made towards the target from any quarter and from slightly below or above.

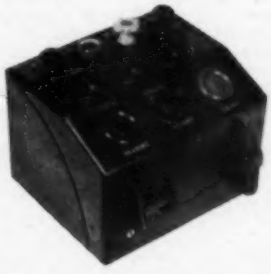
Hughes Aircraft Company developed the system and it was fitted to such intercepters as the F-86D, F-89D and F-94C. The gun-firing F-86K carries the MG-4 fire control developed by Autonetics division of North American. But such systems are already superseded by the data-link control of the autopilot from the ground which is a standard component of the SAGE defence system. To fit in with this, Hughes have produced the fire-control for the Convair F-102 and F-106 and Minneapolis-Honeywell have made the MB-5 autopilot for the F-101B. The MB-5 can hold constant speed, Mach number, pitch or bank attitudes and height, or combinations of these. It has a special limiter which allows the aircraft to be flown automatically right up to its airframe strength limitations; and it can be coupled to V.O.R., Tacan, I.L.S., data link or fire control to make pursuit, collision or "snap-up" attacks. Stick-top steering or knob-control are available or only the yaw autostabilizer channel can be operated, leaving the pilot free to fly manually. The F-101B, of course, can carry three MB-1 nuclear air-to-air missiles.

Douglas El Segundo, with the assistance of A.C. Spark Plug, General Motors, Avion and Westinghouse Electric, have produced a similar system called Aero 24A. It will automatically control delivery of bullets, rockets or missiles. Similar facilities are offered by the Lear L-10. Slightly earlier autopilots, installed in most current U.S.A.F. and U.S. Navy military aircraft are the E-10, E-11 and MB-3, the last-named of these being installed in the F-100D and providing automatic toss-bombing control.

A remarkable addition to the F-102 is the Hughes Digitair, a digital machine weighing only 120 lb and capable of performing about 36,750 computations per minute. One of its great advantages is that it can store the predicted position of a target and perform the interception manœuvre under memory control after the data link system has been jammed. It will also record the correct landing order of the aircraft, if this is one of several sent up, and make sure that it returns to base in its appointed order. Digitair computes and carries out the complete interception phase, leaving the pilot free to monitor the overall operation. Both digital and analogue inputs are sampled respectively 28 and 33 times per second; 9,600 subtractions or additions can be performed every second as well as 600 multiplications or divisions and 600 square root extractions per minute. A small scope and a dialling system can be used *in situ* to check every section of the computer before take-off.

The best-known bombing control is probably the combined radar and optical K system of the B-47 with which Strategic Air Command crews have reached a very high standard of proficiency. Though this was retained in early B-52s, it was soon replaced by the International Business Machines ASQ-38, the nucleus of which are the two 400 c/s analogue computers for bombing and navigation, the Raytheon high-speed radar and I.B.M. radar presentation. Other equipment includes APN-89 Doppler by G.P.L., Kearfott compass system, Kollsman astro compass and a General Electric radar-recording camera. The B-52 can with these systems be flown over an automatically computed great circle course, and position and height may be ascertained and fed into a digital section of the navigation computer to determine location. The fixing equipment is used to correct or set up the automatic dead reckoning computer. All radiating systems are manually switched on or off so that the risk of being detected on the ground is reduced to a minimum.

One of the most highly-developed flight control systems is that produced by Bendix for the B-58 Hustler. In this there is no direct link between pilot and control surfaces, since at supersonic speeds he would be unable to control the aircraft effectively. All manual commands are passed directly into the computer which then produces the surface movements required according to the



*Pilot's controller for the Smiths S.E.P.2 autopilot.*

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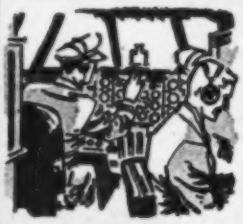
# AD 2300

# Marconi DOPPLER NAVIGATOR

| FOR THE AIRLINE | FOR THE CAPTAIN | FOR THE CONTROLLER | FOR THE PASSENGER |
|---|---|---|---|
| |  | | |
| **...greater economy** | **...better navigation** | **...closer separation** | **...better service** |
| The increased accuracy of navigation which the AD 2300 makes possible and the continuous flow of information which reveals instantly the effect of weather changes on the courses and speeds made good, enable pilots to achieve optimum flight paths. Self-contained navigation maintains your flexibility in operation and helps you to operate regularly and economically. | The AD 2300 series provides automatically and without reference to ground based aids: (a) Position in latitude and longitude. (b) Distance to go on a 'leg' or to destination on a 'great circle' or rhumb line track. (c) Wind speed and direction. (d) Ground speed. (e) Drift angle. (f) Steering information to Flight System or Autopilot to maintain the selected track. | The AD 2300 assists the pilot accurately to maintain his planned track. (The steering information can be fed directly into an Autopilot or flight system if required). It also enables the navigator to give ATC precise and reliable position reports and accurate E.T.A.'s and to keep them under constant review. | The advantages which the AD 2300 brings to the navigator, pilot and controller result in aircraft keeping more closely to their flight schedule and thus reducing frustrating and money wasting delays for the passenger, even when he is flying off the beaten track on routes where beacons and other ground based aids are few and far between. |

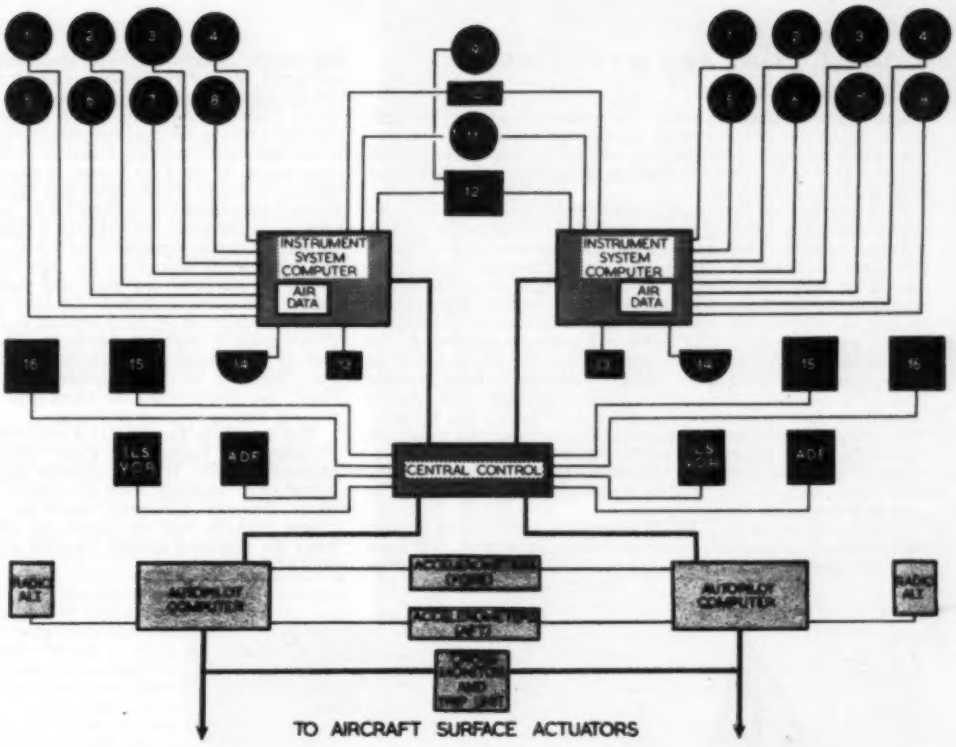
*Marconi's have been in quantity production with Doppler Navigators since 1954. Types AD 2000, 2100 are military types supplied to the R.A.F. and Commonwealth countries. The AD 2300 is the type designed specially for civil airlines.*

# MARCONI

***AIRPORT AND AIRCRAFT RADIO AND RADAR SYSTEMS***

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

LA37




1 MACH METER
2 A.S.I.
3 HORIZON DIRECTOR
4 PICTORIAL DEVIATION INDICATOR
5 ANGLE-OF-ATTACK INDICATOR
6 ALTIMETER
7 COMPASS INDICATOR
8 V.S.I.
9 STANDBY HORIZON
10 TRUE AIRSPEED
11 TRUE AIR TEMPERATURE INDICATOR
12 MAJORITY-VOTE UNIT
13 ANGLE-OF-ATTACK SENSER
14 COMPASS DETECTOR
15 VERTICAL GYRO
16 AZIMUTH GYRO

**FLIGHT CONTROL SYSTEMS . . .** *Fully integrated and duplicated flight control and instrument system designed by Sperry (England) for civil airliners.*

flight conditions obtaining at the time. The process of varying stick and control-surface movement relationships is defined as ratio-changing.

For civil aircraft, the autopilot problem has become one of providing flight control for the high-performance airliners soon to come into service. Announced during the last eighteen months are the now well-known Sperry SP-30 and Bendix PB-20, both offering either three-axis autostabilization, full three-axis control with heading, height and speed lock or coupling to V.O.R. and I.L.S. for navigation and approach. Collins AP-101, Smiths S.E.P.2, Sperry A.12 and Bendix PB-10 are already well established in service; and the S.E.P.2, complete with integrated instrument system, is specified for the Comet 4. These systems can all be fitted retrospectively to an aircraft or installed on the production line.

But some companies are working on integrated systems designed from the start as part of the aircraft.

In this field, the Sperry Gyroscope Company, Ltd., which has consistently advocated integration to obtain optimum performance and reliability with minimum installed weight, is working on advanced equipment for civil use, the philosophy of which is illustrated in the block diagram above.

Aircraft information is measured by a dual set of sensing instruments which separately feed port and starboard instrument displays and also a dual autopilot system. Normally one of these autopilot systems controls the aircraft and the other operates as a flight director, allowing visual monitoring of autopilot performance.

In the event of failure anywhere in the system, safety is assured by means of a fault detection system which operates firstly by detecting any discrepancy between the dual autopilot channels and secondly by monitoring the aircraft response and thereby determining in which channel the fault has occurred. If the fault is in the flight director channel, an indication is given to the pilot and, if it is in the autopilot, this can either be automatically disengaged or an automatic change-over can be effected so that the original flight director channel now takes over the automatic control of the aircraft.

The system is so designed that, where applicable, the output member of the autopilot is integrated with the powered flying control actuators. The powered control actuator is arranged to drive the linkage so that auto-control movements appear at the pilot's controls. Simple, positive and accurately calibrated force limiting arrangements are included so that the maximum effort that the autopilot can develop at the control column or rudder bar is effectively limited and the auto-control system can be easily overpowered and disengaged by manual effort.

Where required, an auto-stabilizer mode can be provided, without additional equipment, in which auto-stabilization does not produce any reaction at the pilot's controls.

The instrument presentation is basically similar to that of the well-known Sperry Integrated Instrument System with the addition of the air data information.

Since automatic control is becoming so important for high-speed civil transports, duplication of the autopilot might well become a requirement. The Sperry system is based on this concept; and Lear now offer the L-102 as a completely duplicated system. It is already fitted to KC-135s and will be used in the Boeing 707 and the Sud Caravelles ordered by Air France and S.A.S. One was installed in a Learstar which flew "over the Pole" to Germany almost entirely under autopilot. Lear have, by special packaging, transistorization, printed circuitry and rigid economy of components, reduced the size and weight of each autopilot to half what it was, making duplication a reasonable proposition. The L-102 provides height and Mach number control, beam and omnirange capture and approach coupling, heading control, rate-gyro damping and circuit monitors. It has behaved very well in the Lockheed Jetstar prototype.

Both Louis Newmark, Ltd., and Elliott Brothers (London), Ltd., have made special autopilots for military high-speed aircraft. The Elliott unit provides autostabilization about all three axes with the possibility of automatically or manually adjusting the servo system, controlled by three rate gyros, for various speeds and heights. Certain pitch and bank angles may be stored in a computer and used to hold certain attitudes; and a coupler allows automatic I.L.S. approaches.

The Newmark unit takes its heading and attitude information from a master reference gyro which serves all aircraft systems and supplements this with rate signals from three rate gyros. Control parameters are automatically varied according to height, Mach number and speed sensed in an air data unit. Height, speed or Mach-number lock, and separate autostabilization in yaw or roll

## FLIGHT CONTROL SYSTEMS . . .

can be selected. Both pitch and roll control are effected through electro-hydraulic servos moving the ailerons as elevons— a feature which has been mentioned as part of the Sea Vixen control system. This avoids using the slab tailplane which is sensitive to very small displacements.

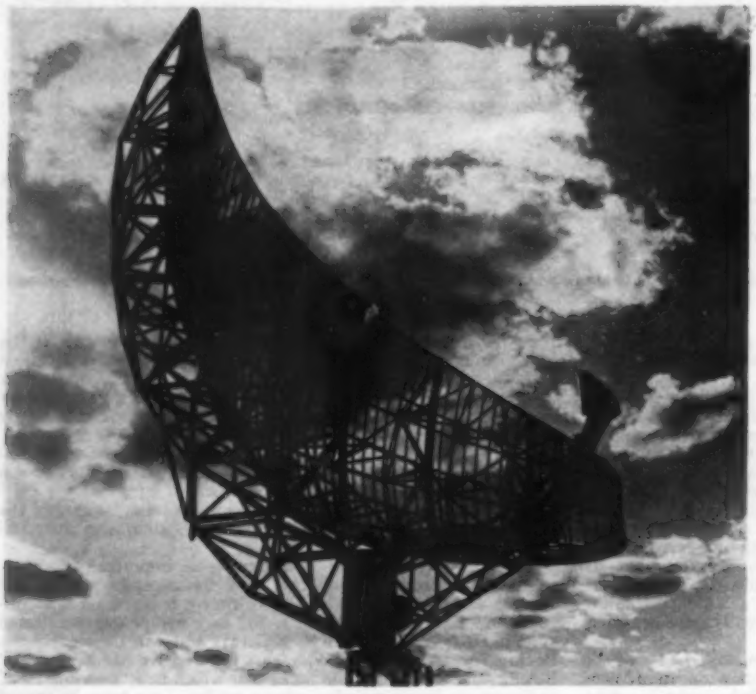
Both Sperry and Minneapolis-Honeywell have produced helicopter autopilots offering either short-term stabilization or full hovering control. These services are also provided by the Mk 14 helicopter autopilot produced by Louis Newmark, Ltd. Rate signals for short-term control are derived from three rate gyros, while long term references are taken from the normal flight instruments. A special yaw computer relates directional control to engine power setting. The servos are arranged parallel to the normal control runs and force sensers allow the pilot's inputs to be superimposed on autopilot signals. Hovering with the fuselage headed in a constant direction, regardless of height and attitude changes, is also possible; and a barometric height can be held. The inner autostabilization loop confers characteristics similar to those of a fixed-wing aircraft on the helicopter. If suitable references are available, hovering over a fixed ground point is possible. Collective pitch remains manually controlled throughout. The system weighs only 35 lb.

The Sperry A.L.3 and A.L.30 Gyropilots for business aircraft and small airliners are now well established in service. They are light and simple electro-pneumatic units using pneumatic servos and offering manœuvre control and heading and height lock. They are fitted in the Friendship, Herald and Noratlas. A logical development of these was offered last year in the form of the Flight Director Gyropilot. Here, the well-known Zero Reader is coupled with the electro-pneumatic autopilot, allowing monitoring of the automatic coupling function with a normal panel-mounted instrument. If the Zero Reader is already carried, the additional coupler required is very small and light. The full range of Zero Reader manœuvres, including I.L.S. approach, may be coupled directly to the autopilot, offering a range of uses almost as wide as that of airline equipment in a very small and simple system.

Several small autopilots for light aircraft were described in *Flight* for April 12 last year; and these are now established in service. Simplest of them is the Lear Arcon (Automatic Rudder Control) which, as its name implies, is a rudder control using rate gyro signals. It has been cleared by C.A.A. for continual use from take-off to landing and is normally permanently engaged. Apart from assisting in course holding during long cross-countries, Arcon can also prevent the spiral dive which is one of the main hazards during instrument flying.

The ingenious Tactair T-3 is now cleared for use in many types including the Cessna and Piper light twins and many single-engined aircraft. It uses standard artificial horizons and D.I.s ingeniously modified with pneumatic pick-offs to act as references. Further pneumatic valves are used to direct pitch and course changes; and the servos are pneumatic bellows operated from the standard aircraft vacuum system. Installed weight is only 12 lb.

C. M. L.



# AIR TRAFFIC CONTROL

### *Equipment to Soothe Aviation's Biggest Headache*

THERE can be few delusions left about the preparedness of air traffic control to meet the jet age. Sufficient has been said and written in recent months about its growing pains and problems to generate a fine state of anxiety, if not among Mr. Average Passenger, at least among those whose responsibility it will be to introduce, control and operate jet aircraft into a world of propeller-driven traffic. Analysis tends to show that it is not present difficulties and delays which are the cause of the pother, but the prospect that air traffic services will fail to develop sufficiently to meet the accelerating demands upon them of the technological progress and sheer weight of numbers of the aircraft that must be controlled.

The big fear is that control at periods of peak activity will become saturated to a point where it will only function sluggishly, causing long delays in the traffic stacks that are anathema to the thirsty jets. Yet development of new and revitalizing equipment for air traffic control is by no means at a standstill; it has rarely been more intensive or financial programmes more impressive in size and scope. No short cut exists and no panacea for the A.T.C. problem has been found, or is ever likely to be found. The gap between experiment and practice has never before been so wide.

The variety of systems and equipment offered by the electronics manufacturers presents a bewildering array. There are many more solutions, it appears, than there are problems. Holland has devised an air traffic system of her own, and so, to a degree, has Belgium. In Decca and Dectra, the United Kingdom is offering what is firmly believed to be the best *en route* navigation aids to facilitate traffic control. As each problem is aired in I.C.A.O. conference, and solutions suggested, new systems, new problems and half a dozen new solutions appear to demand a place in the queue for urgent international discussions. The variety of radars alone requires careful explanation, and much has been done to improve the presentation to the controller of radar-based information.

The best aids for controlling air traffic can only be found by

careful and often protracted and painstaking evaluation under representative conditions. Universal practices and universal A.T.C. systems, desirable as they are, may have to be subjugated to local needs and local budgets; but new aids are urgent now. By the end of this year the first of the big jets will have started operations on the world's busiest air routes over North America, the North Atlantic and Europe.

Because air traffic control today still relies in the main upon position reporting from the cockpit for the separation of traffic, accurate navigation assumes continually greater importance. B.O.A.C.'s deputy flight services manager, E. W. Pike, has said that "today the separation problem is completely dominating the navigational problem." The accuracy demanded of position reports on Europe's congested airways system is conditioned by the need to crowd more and more aircraft into the defined air routes. The airways cannot be much further extended without severely hampering military, private and manufacturer's test flying. New U.K. airways introduced to serve the new Gatwick terminal have already swallowed much of the free space in south-east England.

The critical separation problem is still the most difficult to resolve. To the vertical separation afforded by the four-segment quadrantal rule can be added lateral separations of aircraft tracks and longitudinal separations in distance or in time. Although primary reliance is placed upon vertical separation, position and altimeter instrument errors and the use of mean barometric pressure settings can result in wide variations of altitude—much in excess of 500ft quadrantal spacings—even with aircraft employing a height lock on the autopilot. Tests have shown variations of 1,400ft on a modern B.O.A.C. aircraft with known or corrected instrument errors. Yet to employ wider vertical separations is to impose uneconomic restrictions upon operations. The penalties of flying off the flight-planned altitude in a big jet (where the fuel consumption can be equivalent to the weight of one passenger used up per minute) can be 2 per cent up to 4,000ft off flight-plan and 9 per cent up to 9,000ft—a figure approaching the total payload.

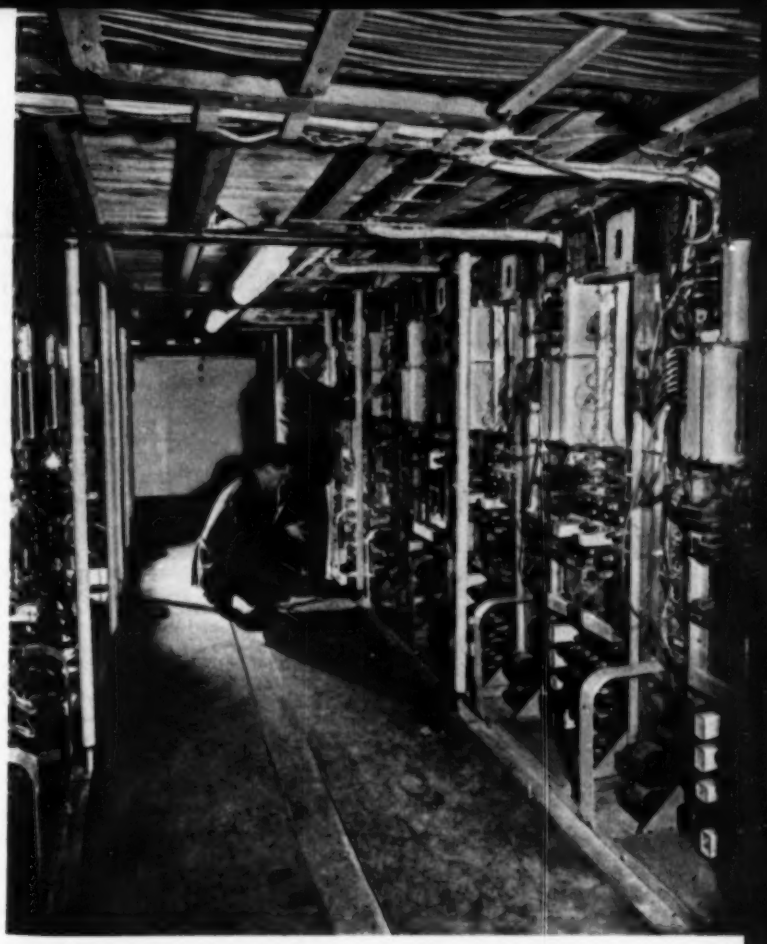
Over the North Atlantic, saturation has been reached on separation by vertical displacement alone, and extended lateral and longitudinal separations of 120 miles have been adopted. With 180 aircraft over the Atlantic at the same time at peak periods little arithmetic is needed to indicate the enormity of the problem. The only way to avoid delays is to reduce separation, and the way to do this is to improve the accuracy of position reporting with a long-range area-coverage navigation aid. The early promise of Dectra as such an aid has been borne out by tests over the Atlantic during the past ten months and there seems good hope that a sophisticated "belt and braces" system such as Decca/Dectra/Doppler will provide a reliable and accurate answer to the position-reporting problem. The time is rapidly approaching when air traffic control and navigation can no longer be regarded as separate problems.

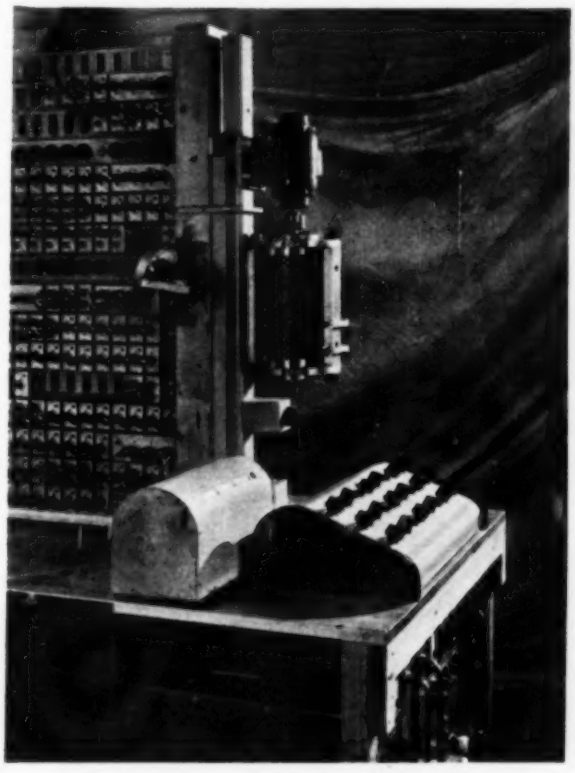
But such close accuracy, 1,500 miles out over the Atlantic, is not to be achieved overnight, and meanwhile A.T.C. officers will still apply their own factors to pilot's position reports. The North Atlantic may well become one of the world's most closely regulated traffic areas and the halcyon days of jet stream joy riding may soon be passed.

One thing is certain; the principle of "see and be seen" transposes a quite unacceptable burden of air traffic responsibility from controller to pilot. The problem is not one of cockpit visibility, but of cockpit workload. Some recent deliberate experiments in the U.S.A. with radar-monitored collision courses and an analysis of 50 air-to-air collisions has provided frightening evidence of the uselessness of expecting pilots to maintain separations by keeping a look-out from their cockpit windows. Collision warning devices, now a stage nearer reality after the technical setbacks of a year ago, could provide a useful safeguard particularly against random intruders into airways, but are no substitute for full control.

Inevitably, the progress of control techniques depends upon the development of radar, of television presentation of information, and of computer assistance to allow the controller to concentrate quickly and simply on making necessary decisions—and nothing else. In the same way, the effectiveness of ground control relies upon improved airborne navigational aids (for better position fixing) and development of position reporting for aircraft by semi-automatic data link, or by airborne teleprinter. The day of the small bright P.P.I. tube in a darkened control room is passing; the strain is too great and the information is required by too many people at once. Larger screens with coded, synthetic-display presentation can be studied effectively in better lit rooms. If there is a pattern emerging for the organization of air traffic control centres, it is for the use of more and better radar, with overall monitoring of the complete airways system (and telephone or microwave link between adjacent radars and the controllers) three dimensional display, automatic ground-to-air communication, and electronic aids to replace the written-out tally system of passing flight progress reports.

One of the more ambitious efforts on these lines is that of the Dutch firm Hollandse Signaal Apparaten of Hengelo who last year





*Computers will replace manual processing in future traffic control centres. Above is the computer of the R.R.E. defence system at Malvern while below is the memory drum and wind-data input panel at SATCO, which can store 1,000 flight plans.*

## AIR TRAFFIC CONTROL...

revealed details of the laboratory model of SATCO—Signaal Automatic Air Traffic Control. In developed form it is intended to present the air traffic controller with the information, time and opportunity to act solely as the monitor of an automatic system. The principles guiding the design were that the system (1) should not require any major change in existing flying or air traffic control procedures; (2) could be used without additional special equipment in aircraft or adjacent air traffic control centres; (3) in emergency could be overruled by the controllers; (4) should be able to deal with all types of aircraft; (5) should be adaptable to particular control centres and airports; (6) should be gradually introduced into the present system, building up eventually into an integrated, fully automatic one and (7) should at all times be guaranteed to fail safe.

The full installation consists of automatic data processing equipment, automatic radar equipment and automatic communications equipment utilizing normal teleprinter networks. Initial flight data—telex or flight plan from the departure airfield, or *en route* information from a position report from the aircraft, a telephone message from an adjacent A.T.C.C., or from the radar to which the system is coupled—is fed into the data processing equipment either by manual teleprinter or by automatic transfer from telex lines. Until positive information is obtained about the entry of the aircraft into the system or its readiness to take off, the information is merely encoded and stored. When required, the computer calculates the expected time of arrival of the aircraft at the reporting positions along its route, checks the flight path against the other flight paths already in the system and calculates a safe path which will deviate as little as possible from the original flight plan. The results of these calculations are stored on a memory drum and presented to the controller on a "tote" type of display—showing the call-sign, height and type of aircraft—and on a dynamic "clear-view" P.P.I. display giving the position of the aircraft in three dimensions. Each aircraft under control is identified by special symbols.

The progress of the aircraft through the system is subsequently checked either by position reports from the aircraft, or by radar. Verbal position reports from the aircraft are inserted manually into the system, the clearances are recalculated and the controller warned of any changes needed. Special long-range 10cm tracking radar and 25cm surveillance radar with variable-speed Moving Target Indication and a solid cover of up to 200 miles is proposed.

At this stage of development, SATCO represents little more than a computer system used in conjunction with advanced but not revolutionary radar installations. The inventors propose, however, the addition, either separately or together, of automatic radar and automatic data transfer. The full system involves automatic traffic planning and clearance calculations with ground-to-air and air-to-ground data links, with coarse advanced planning (e.g. daily scheduled flights leaving at known departure times) stored in the memory drum up to 12 hours ahead of the movement.

This function of automatic traffic planning is based upon an artificial block separation system unique to SATCO. Extra charts or beacons would not be needed, but for convenience in computing, airways and approach tracks are divided into blocks of air space the width of the airway, 3.5 n.m. long and 500ft high. The flight path is regarded by the computer as being within a series of blocks each of which is either "occupied," or becomes "reserved" when the aircraft is about to enter. Thus occupation and reservation of blocks and the relevant times are recorded on the magnetic memory drum, and the paths of new aircraft entering the system can be compared with those already stored. The computer is designed to select the shortest flight paths where the number of blocks for the required separation would not conflict.

SATCO is to be tried out at Schiphol airport, and the firm say that it could be ready for production in 1960.

Although Holland's future air traffic control system is advanced in its conception, neighbouring Belgium has been among the first to make practical use of the advantages of televisual presentation of information on a large screen. Because of the severe separation problems on east-west and west-east traffic, the special Belgian government agency Régie des Voies Aériennes adopted radar surveillance early on to reduce separations, but are unusual in marrying this with the identification features offered by automatic visual V.H.F. fixing and T.V. radar interpretation.

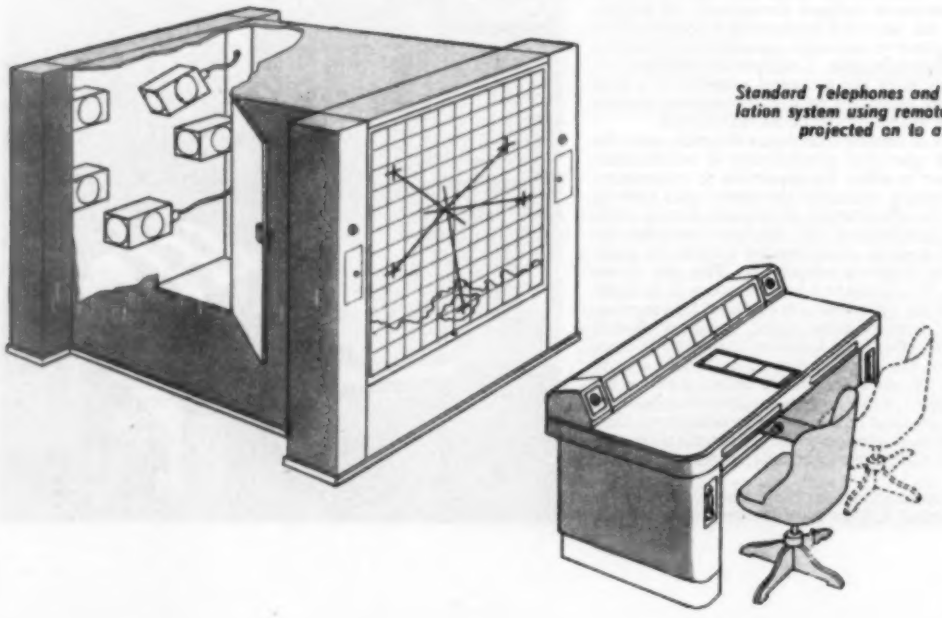
The Belgian system is an integration of the work of three companies, Standard Telephones and Cables, who manufacture the PVT.1 automatic triangulation system; General Electric, who manufacture the ASR.2 surveillance radar, and Compagnie Générale Française de T.S.F.-Société Française Radio-Electrique (C.S.F.-S.F.R.) who are responsible for the excellent image transformer that turns radar video into a television display.

The Standard Telephones and Cables system provides instantaneous visual presentation to the controllers of C.R.D.F. bearing traces on a 60in square projection screen, marked with a map of the service area and indirectly illuminated from the rear in a colour contrasting with that of the D.F. traces. The map is in black outline on a clear ground and includes a reference grid, significant landmarks and the more important topographical features. The front face of the screen is treated to reduce reflections from bright objects in the traffic control office so that normal overall lighting is quite practicable. During a brief transmission from an aircraft on airways control frequencies, the PVT.1 will bracket the position of the aircraft on the screen from five outlying C.R.D.F. stations.

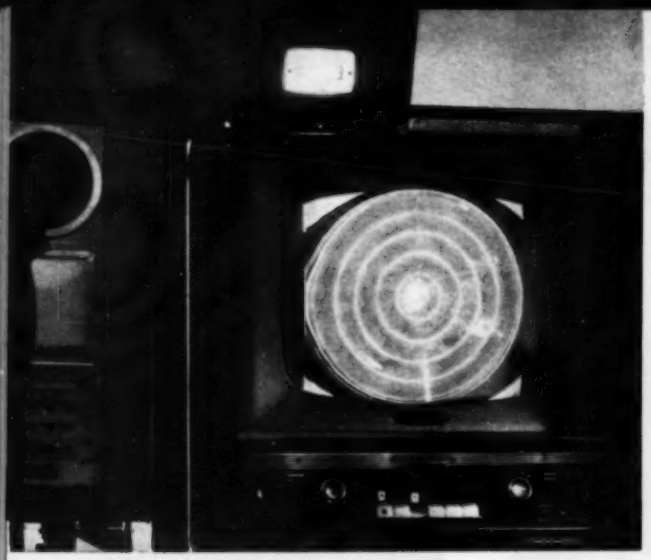
The Standard Telephones equipment was installed last year and the results have proved very satisfactory. The integration of the D.F. and radar facilities arose from the difficulty experienced by the Brussels controllers in identifying individual blips on the G.E. ASR.2 surveillance radar during heavy traffic.

The C.S.F.-S.F.R. equipment is the Image Transformer T.I.440 which transfers the P.P.I. radial radar trace on to a standard 625-line television screen. C.S.F.-S.F.R. also supplied an interference eliminator, which, like the Image Transformer, embodies a memory tube and reduces clutter, including interference from other radars operating on the same frequency.

The final step taken by the staff of Régie des Voies Aériennes, under the direction of M. R. Lecomte, was the combination of the P.P.I. radar and C.R.D.F. triangulation on to a common screen. The PVT.1 system is still being evaluated and will form the basis of a more ambitious project in which elevation information will be added to the plan position indication by a method not yet revealed.



*Standard Telephones and Cables automatic triangulation system using remote C.R.D.F. bearings visually projected on to a glass map screen.*



*Left, automatic triangulation and surveillance radar combined into a TV presentation in the Belgian control centre which is now in operation. Right, the Light Aircraft Binary Information Link equipment, made in "book" form with printed circuits on each "leaf."*

Other applications for television projection of cathode ray tube information include work in both France and America. A French proposal is to present the aircraft position signal from the Radio Mailles area-coverage system (mentioned on page 661) on a cathode ray tube on the ground and project it on to a large screen. Height information would also be obtained and displayed. A further proposal is to re-transmit the complete plot from the ground to scopes in the aircraft to provide visual collision-warning information to the pilot.

The Compagnie Française de T.S.F. television projection equipment has been adopted for trial use in the U.S.A. by the C.A.A. Another form of screen presentation of cathode ray tube information is that developed in Britain by Kelvin Hughes in conjunction with Ilford and the Ministry of Supply. This is also being evaluated by the U.S. Civil Aeronautics Administration, who have installed three at their technical development centre, in Indianapolis, to project on to a plotting table air traffic information from cathode ray tubes fed by two radar systems spaced 50 miles apart.

The Kelvin Hughes equipment is the Rapid Processing Photographic Projector which, although having a slight time lag in presentation of the radar trace information on the screen, has the advantage that a permanent record of the operation is obtained. A 35mm film of the P.P.I. tube is instantly processed and projected on to a screen graded in size according to the intensity of illumination required. Positive or negative image is chosen according to ambient lighting levels. The equipment can be used with cathode ray tubes or for recording from a Charactron shaped-beam tube or other forms of synthetic display. It will operate continuously for a period of 24 hours on a 1,000ft reel of film.

Processing time is about six seconds for a negative image and twelve seconds for a positive; this lag between cathode ray and screen presentation can be shortened, but only at the expense of contrast and permanence. Normally the projectors are operated in pairs, optical registration of the projector being achieved with a double-sided mirror.

One of the best known synthetic radar display systems is the Stromberg-Carlson Charactron shaped-beam tube. Patented as early as 1940 but not developed until comparatively recently, Charactron forms symbols or characters by extrusion of the electron beam through a stencil-like mask and then places the character at any desired position on the face of the tube. Stromberg-Carlson claim that Charactron provides the brightest, smallest and most easily generated characters. The code symbols can be combined with the conventional type of sweep display.

Last December, Stromberg-Carlson announced a new adaptation of Charactron (which is, incidentally, in production as the basic display element for the SAGE air defence system). Called C19Q, it is designed to display simultaneously radar or T.V. images with identifying letters, numerals or symbols and is intended to provide a visual link between complex electronic systems and human controllers. The display consoles of the C19Q can be integrated into the fully automatic, high-speed computing systems which must eventually replace the hand-written flight strips in control centres. With Charactron, flight information is placed on to a flight strip by means of a keyboard under the care of a controller. A typical air terminal display would consist of a conventional radar presentation in the centre of a rectangular cathode ray tube, an inbound flight strip presentation on one side, an outbound strip on the other and an adjacent keyboard. Any number of Charactron tubes can be used to cover additional areas and to reduce the total number of symbols. Advantages claimed by the manufacturers for the C19Q tube include the possibility of enlarging, blinking, intensifying or dimming identifying signals. Production SAGE-type tubes have a life of several thousand hours.

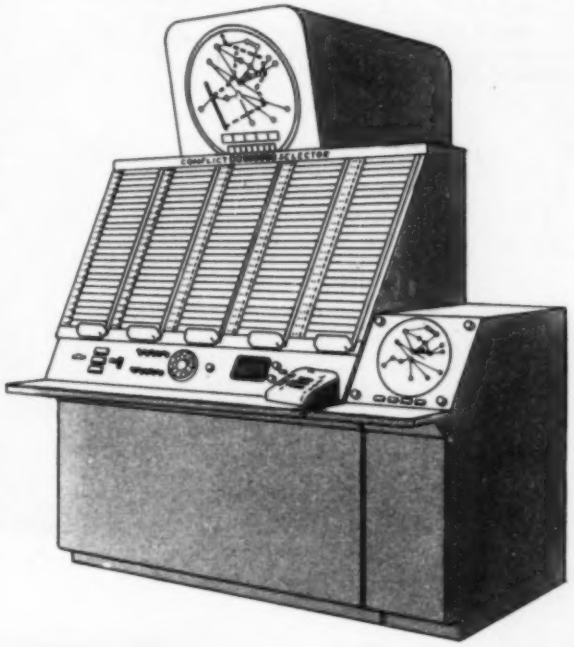
The method of operation proposed is that when outbound clearance is requested by an aircraft, the outbound controller will insert the call-sign and information about the flight on to his keyboard, and the clearance request will be relayed automatically to route control for confirmation. When clearance is received, the aircraft will be tracked to the departure gate by the radar in the centre of the display; the blip will have a tracking symbol and alphanumerical data about the flight superimposed upon it. Aircraft could be quickly identified by comparing the blip symbol with a flight strip at the side. Controllers would not have to write or move strips along the boards, and data on all flights would be available without cluttering the display; the identification of radar targets would also be much improved.

Emergency situations could be dealt with by pressing a change button and inserting new instructions on the keyboard. The revised situation will be shown on the flight strip. As with the SATCO system, the keyboards could be used to set up flights by air route traffic controllers and to feed height, speed and departure time into the memory of a computer which would be able to assess and reject conflicting traffic from other flight plans. Fewer delays should result from the facility to deny or modify departure requests immediately.

Stromberg-Carlson have announced this year another specialized version of Charactron, namely the Indicoder binary decoding tube. It will have a 1½in screen on which is projected a numeral an inch high. A group of tubes used in combination form an electronic display board of detailed information on any number of aircraft at an airport. Production models will be 12in long and the numerals displayed will be visible over a wide angle for about 20ft under ordinary lighting conditions.

The possibilities of automatic or semi-automatic data transfer are attracting the attention of many electronics firms. Stromberg-

*The radio sector console of the General Precision Laboratories New York air route control system, due for trials in 1960.*



## AIR TRAFFIC CONTROL...

*Left, two of the 28 cabinets which make up the Avco Voiscan. Operators are illuminating blips for automatic tracking.*

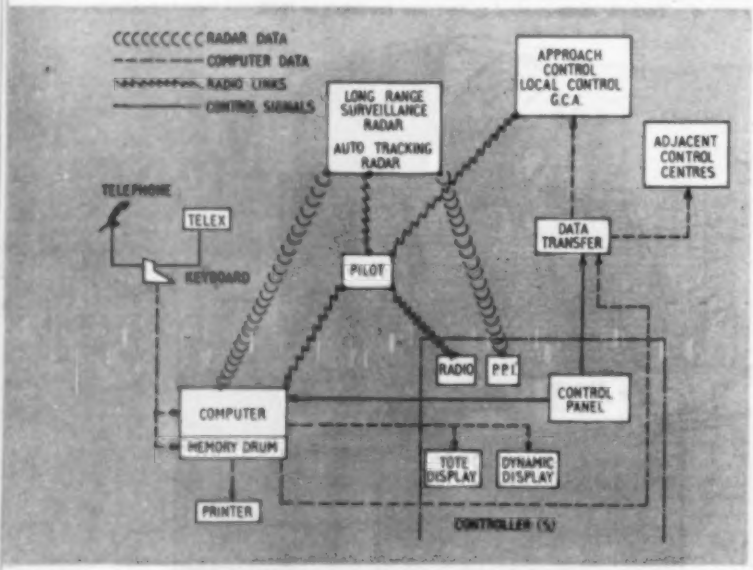
Carlson are probably the first manufacturers to have given serious consideration to the need for limited-application simple and light-weight mobile equipment. The purpose of their new LABIL—light aircraft binary information link—is self-explanatory. Data is entered into the link by the aircraft pilot or observer and transmitted automatically on demand from the ground via the voice channel of existing communications equipment.

The unit operates in conjunction with any voice transmitter/receiver. The operator adjusts selector knobs (13 data categories, each covering from one to four figures, is the present transmission limit) and the message is stored in teletype code form until the transmit key is pressed in response to a message request signal—as indicated by a panel lamp. Information could also be fed in automatically from flight instruments through transducers. The airborne unit is transistorized, measures 6in × 10in × 13in and weighs about 25 lb.

The message as received on the ground is checked for error due to noise interference and printed out by teletypewriter. Error sensing in the receiving unit is accomplished by transmitting each character over the link twice. The first character is stored in one register and the second version of the same character in another. A comparator examines the registers and converts each character into teletype form only if complete agreement is obtained. Message transmission with the present LABIL design occupies five seconds and printing-out 11. Characters failing this error check appear as blank spaces in the printed text and can thus be identified, since the probability of character rejection due to an error greatly exceeds the rate at which undetected errors are passed. An error-rate check indicates the point at which the link is no longer useful due to noise interference. Scope is provided within the system for requesting re-transmission of a message to fill-in omissions and to tell the airborne operator that the message has been received.

Equipment for providing aircrews with teleprinted information relayed from ground sources is being built—initially in small quantities—by Standard Telephones and Cables in association with Creed and Co. The system is being evaluated by B.O.A.C., who have carried out trials over the North Atlantic (the first successful test was made two years ago) using teleprinted weather information relayed from a station on each side of the ocean radiating about 2 to 5 kW carrier power. The airborne equipment provides four crystal-controlled channels, in the 90-130 kc/s range and the receiver will print with accuracy on input signals of one-third of a microvolt. The teleprinter operates at up to 100 words/min and weighs 35 lb. T.C.A. are evaluating similar systems using Federal Telecommunication Laboratories equipment. Air France and Swissair are about to start evaluation and Marconi also has an interest in this field.

Competition for development contracts for automatic and semi-automatic equipment for air traffic control has been very intense within the United States. The Airways Modernization Board has had a proportion of the C.A.A.'s operation and regulation budget—totalling £26.6m in 1957, £44.3m in 1958 and £62.5m in 1959—to spend on research and development of air




*Diagrammatic layout of the Dutch SATCO control system.*

*The Stromberg-Carlson Charactron synthetic display presenting aircraft traces as letter-number-symbol groups.*

*Left, the P.P.I. of the Cossor CR.21 surveillance radar with M.T.I. and circular polarization switched on.*

traffic control, and the Board received 13 proposals from 31 companies for experimental projects in their planned research programme. The eventual £1.5m award for the design, development and manufacture of the *en route* phase of the AMB semi-automatic traffic control data and processing system has gone to General Precision Laboratories.

The first model of the new G.P.L. system should be installed in the New York air route traffic control centre in early 1960, where it is intended to assume eventually the complete air traffic load of that very high density traffic area. The data processing equipment is "designed to function with existing procedures and facilities as well as future changes, and . . . provides for the reception, correlation, computation, display and exchange of air traffic control information." It is, in fact, designed to perform routine tasks for the controller and present information which requires his decision. The computer is capable of processing 400 flight plans an hour (1,000 can be stored) and preparing flight progress strips at the rate of 1,600 an hour, but if conflicts are discovered while comparing input data, they are presented to the controller for corrective action.

There is strong support for the decision to limit the computer's function in this way, at least until the infallibility of decision-performing electronics is very thoroughly proved. In any case, the final say—such as re-routing to avoid bad weather, or exceptional action when an airfield is partly unserviceable—must always be kept under human control.

An almost complete automatic computer is Volscan, engineered by the Crosley division of Avco. It is "an analogue computer which has stored into it every possible landing approach problem that may arise. Since the computer has the answer before the problem is submitted it takes a fraction of a second to advise the operator of correct approach instructions." As the pilot follows relayed instructions an automatic tracker follows the aircraft, feeding positional information to the computer. Automatic adjustments are made in later instructions if a pilot does not follow earlier orders implicitly. Two units are being delivered to the

*Kelvin Hughes rapid processing projector system in use in the C.A.A. control centre at Indianapolis. The surveillance radar scope is photographed and the film processed in a matter of seconds to allow visual projection on to the plotting table.*

*Display of the Raytheon A.T.C. radar. Map details are electronically superimposed, together with M.T.I. and circular polarization.*

## AIR TRAFFIC CONTROL . . .

U.S.A.F.; one at Eglin A.F.B., Florida, and another for later installation at Wright-Patterson A.F.B., Ohio.

A runner-up for the AMB contract was the system proposed by International Business Machines Corporation, called Automatic Position Telemetering. This, it is claimed, can be integrated with automatic data processing machines and has the advantage of low airborne weight. A.P.T. operates by measuring the time of arrival of four coded pulses of U.H.F. energy at four ground receiving sites located about 20 miles apart. Pulses sent from aircraft are received in a co-ordinate conversion computer to plot the aircraft's location; altitude data could be added by additional pulses. The accuracy predicted is 0.05 miles within the station network and 1.5 miles at 90 miles range.

Whatever the prospects for computer methods of easing the task of the air traffic controller, current systems rely heavily on surveillance, airfield and precision approach radars. Present work in this direction is directed particularly towards extending *en route* radar coverage. The very extensive programmes introduced in the U.S.A. and Canada for coast-to-coast coverage are examples in point and the big 40ft Raytheon L-band antennae are spreading in a vast (and highly expensive) network across North America.

Radars in use for air traffic control purposes may be roughly subdivided by wavelengths. It is generally true to say that the choice of wavelength is made by consideration of the range, the pulse power required and the necessity to avoid clutter from permanent echoes, rain and cloud. Interference is reduced by the use of longer wavelengths (it increases rapidly between the usual microwave bands of 25cm through 10cm to 3cm) but resolving power and the possibility of gapless cover fall off. For close delineation, such as is required for airfield surface movement indicators (A.S.M.I.) wavelengths of 3cm are usual. London Airport's Decca A.S.M.I. is an 8mm band radar, which will distinguish the lights along the Bath road or, as on one occasion, a lone policeman lost and wandering in the fog.

For convenience, each band is represented by an alphabetical symbol; thus the Q-band is 8mm, the X-band is 3cm, and so on up to the usual maximum in use of 50cm (L-band). For radars of 23cm or less, circular polarization to reduce rain interference is regarded as essential.

Another technique, moving target indication (M.T.I.) has been adopted to suppress permanent echoes. Long-wavelength radars with M.T.I. give a performance in clutter conditions superior to their shorter wavelength counterparts.

Advancing knowledge in radar design is making possible improved *en route* surveillance radar, new and better methods of radar siting combined with centralized presentation and first steps towards the analysis of flight progress by digital computation. The M.T.C.A. has recently issued a draft specification for a surveillance radar that will provide a radius of cover of 85 n.m. over 5,000ft; three such radars could give coverage over most of the U.K. F.I.R.s. Microwave links, such as that by Marconi, would bring the P.P.I. displays directly into control centres distant from the aerials. The Marconi SX.101 radar link will relay one, two or three radar presentations over hundreds of miles, if necessary, so that a complete picture from several radars may be concentrated in one centre.

Height finding radars have a greater use in determining aircraft vertical separations than they do in determining absolute height (where their accuracy may be in doubt) but they serve a useful purpose where the controller is not in communication with the aircraft displayed on his scope or an altimeter failure has occurred. The general use of transponders for a secondary radar surveillance system still appears to be some way off. Although the advantages are well-known, general agreement on specifications must be reached and installation completed. America's Airways Modernization Board has evaluated 12 Eastern Air Lines flights equipped with Wilcox Electric Co. transponders; and equipment for using beacon information is now operating at Idlewild, Newark and La Guardia A.T.C. towers. Other firms offering transponders are A. C. Cossor, Collins Radio, F.T.L., Radio Corporation of America and the Stewart-Warner Corporation.

A considerable number of manufacturers are engaged in the production of radars in Europe and North America and it is not possible to list them all. Brief mention should be given, however, to Marconi's 10cm (S-band) SR.1000 radar transmitter/receiver which has been designed for long-range cover. Features claimed for it are novel construction to give easy maintenance, compact packaging and a built-in monitoring system. An L-band apparatus by the same manufacturer is the type SR.1030. Marconi offer in addition a range of 25 cm and 50 cm surveillance radars, airfield control radars and height finding equipment. They hope to offer soon data handling equipment designed to accept information from radar sources via a tracking group as well as from teleprinter links and R.T. channels and to display it on bright cathode ray tubes in the form of an up-to-date P.P.I. showing identification letters and heights. The system will have a storage capacity of up to 160 tracks available for onward transmission to adjacent A.T.C. centres by data links, and for input to a computer. A system on these lines was shown at R.R.E., Malvern, and described in *Flight* for May 2.

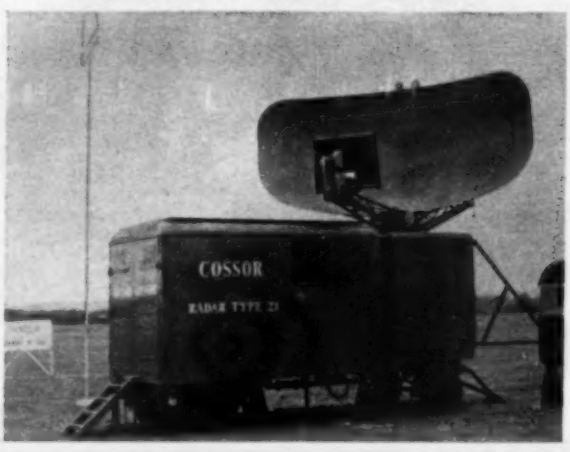
The Cossor Radio company have developed in addition to their compact high power CR.21 10 cm surveillance radar with M.T.I. and circular polarization, the CRD.23, "a new display system which anticipates the air traffic problem for several years to come." The system exploits the unused time between successive radar scans to present up to ten identification numerals against target echoes. A range and bearing marker may also be positioned anywhere on the display and rotated to give the bearing and range between any two points. Any number of displays may be used and located up to two miles or more from the aerial, and the centre of rotation of a display can be off-set up to 60 n.m. Arrangements are incorporated so that a particular echo can be passed over to a controller covering an adjacent section without breaking continuity of plotting. Facilities are offered for video mapping and for presenting CRDF information injected into the P.P.I. display.

Developments in France include an S-band (10 cm) radar manufactured by the Société Nouvelle de l'Outillage R.B.V. et de la Radio-Industrie. It is being used in Brussels over the period of International Exhibition by Régie de Voies Aériennes Belges. The equipment is designed to plot simultaneously the three space co-ordinates of any number of targets; the height-finding feature is claimed to be very accurate—a tolerance of 700ft at 100 n.m. is given.

Air traffic control presents such a variety of bewildering and urgent problems that it is hardly surprising that international regulation lags behind advancing technology. New equipment is being applied to solve the demands for closer separations, unhampered climb-outs and let-downs of jet aircraft and above all, relief of the heavy workload of pilot and controller alike. The early promise of radar is being fulfilled with the advanced equipment now coming into service but the problem of obtaining, transmitting, handling and storing data remains. Some of the methods proposed for handling data are reviewed in this article; how they will be used in practice will depend upon the results of protracted evaluations. Suitability can fairly easily be determined; to achieve the standard of reliability required will be a long and painstaking task.

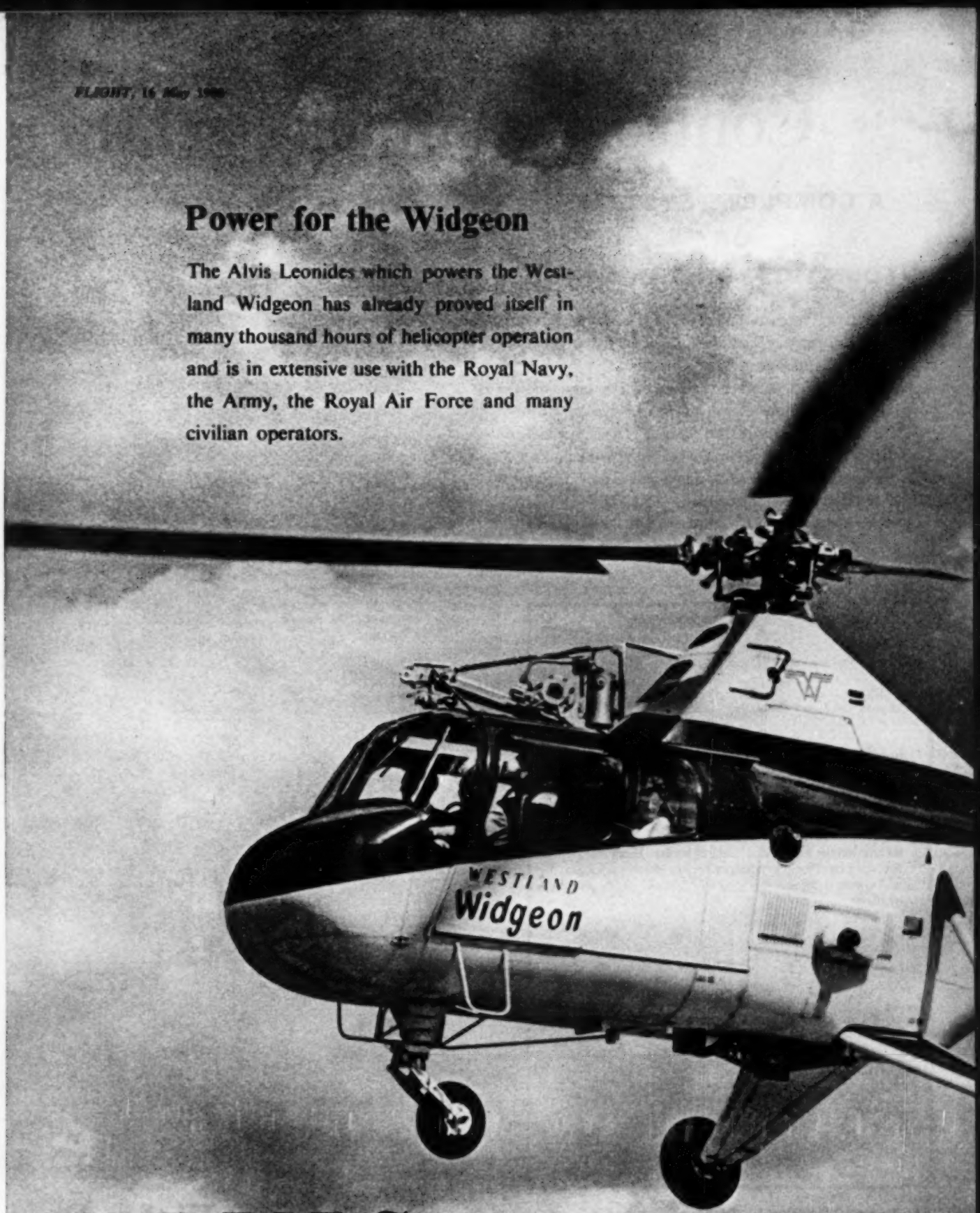
A. T. P.

*Cossor CR.21 in a caravan. The quarter-wave plate is raised in front of the aerial horn to produce circular polarization.*



# Power for the Widgeon

The Alvis Leonides which powers the Westland Widgeon has already proved itself in many thousand hours of helicopter operation and is in extensive use with the Royal Navy, the Army, the Royal Air Force and many civilian operators.




# ALVIS LEONIDES AERO ENGINES

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# Control from take-off to

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The S.E.P.2. Automatic Pilot is backed by over half a million flying hours' experience and is in use or on order for 24 major airlines. With its outstanding improvements in pre-selected heading control, barometric height and speed lock, it is the 'heart' of the Smiths Flight System when set for automatic operation, and controls the aircraft through virtually every phase of flight.

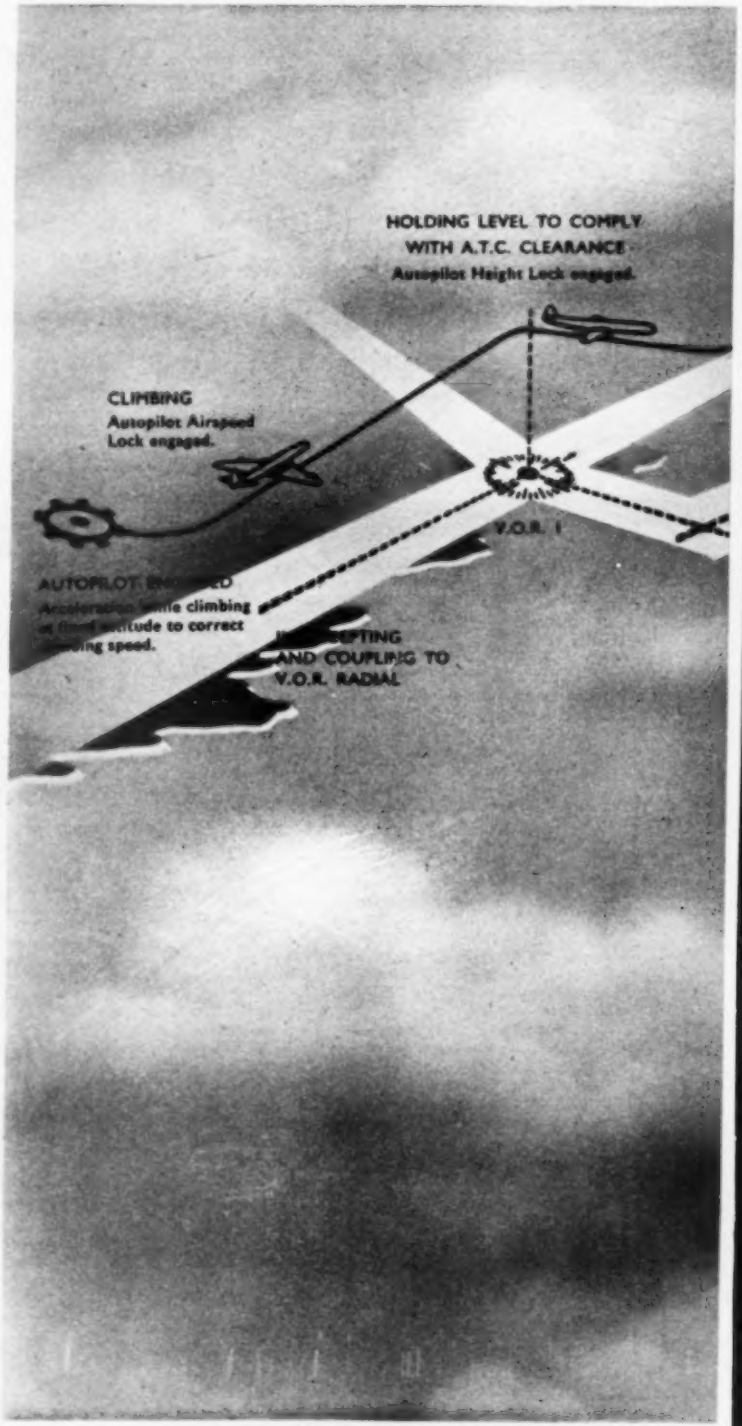
*Twin Director Horizon Indicators*

*Twin Beam Compass Indicators*

*Engage and Trim Indicator*

*E.2. Stand-by Magnetic Compass*

*S.F.S. Selector*

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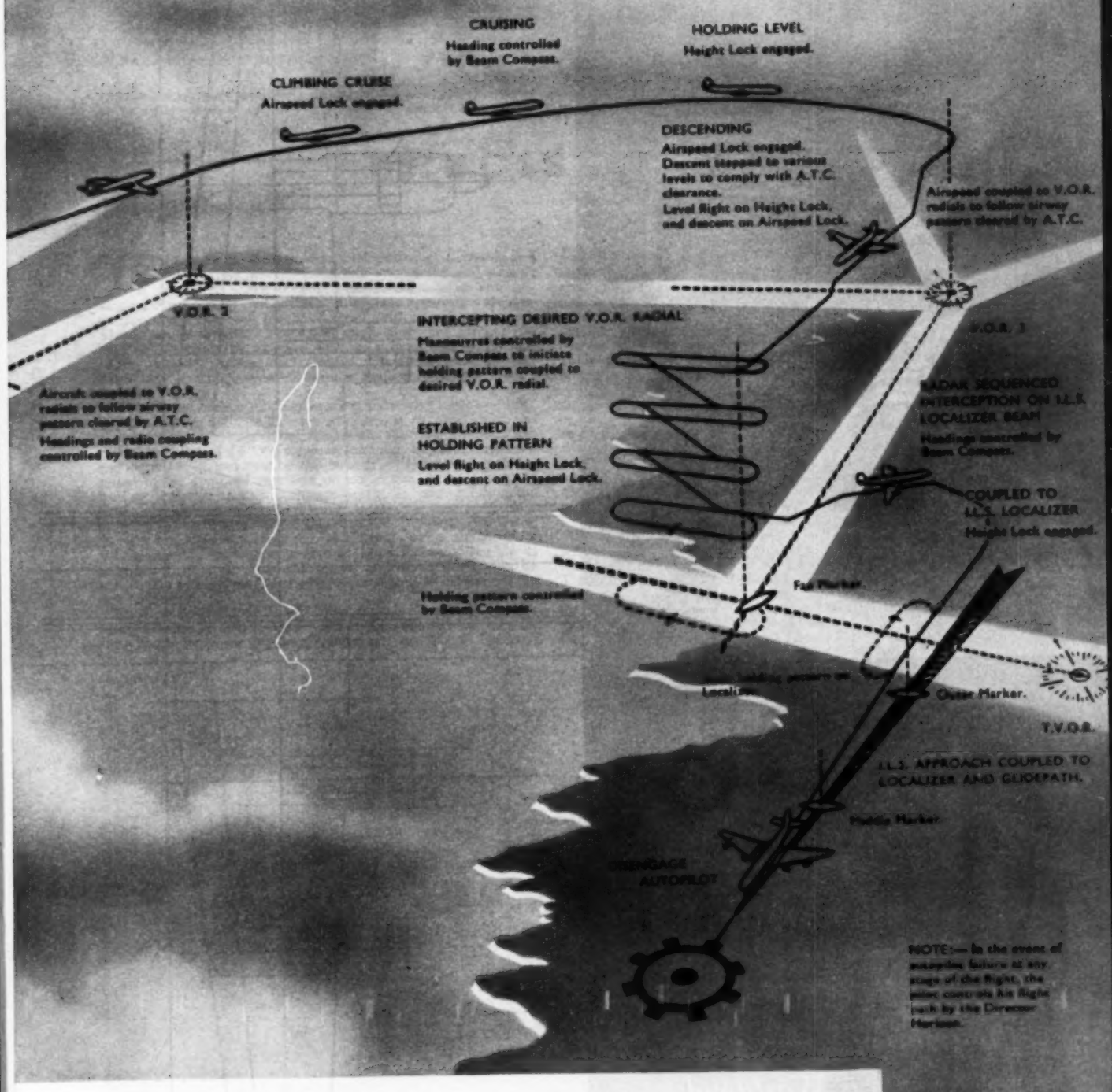
# touch-down


CRUISING
Heading controlled by Beam Compass.
HOLDING LEVEL
Height Lock engaged.
CLIMBING CRUISE
Airspeed Lock engaged.
DESCENDING
Airspeed Lock engaged.
Descent stepped to various levels to comply with A.T.C. clearance.
Level flight on Height Lock, and descent on Airspeed Lock.
Airspeed coupled to V.O.R. radials to follow airway pattern cleared by A.T.C.
V.O.R. 2
INTERCEPTING DESIRED V.O.R. RADIAL
Manoeuvres controlled by Beam Compass to initiate holding pattern coupled to desired V.O.R. radial.
V.O.R. 1
Aircraft coupled to V.O.R. radials to follow airway pattern cleared by A.T.C.
Headings and radio coupling controlled by Beam Compass.
ESTABLISHED IN HOLDING PATTERN
Level flight on Height Lock, and descent on Airspeed Lock.
RADAR SEQUENCED INTERCEPTION ON I.L.S. LOCALIZER BEAM
Headings controlled by Beam Compass.
COUPLED TO I.L.S. LOCALIZER
Height Lock engaged.
Holding pattern controlled by Beam Compass.
Fan Marker
Outer Marker.
T.V.O.R.
I.L.S. APPROACH COUPLED TO LOCALIZER AND GLIDEPATH.
Middle Marker
DISENGAGE AUTOPILOT
NOTE:— In the event of autopilot failure at any stage of the flight, the pilot controls his flight path by the Director Horizon.

# FLIGHT SYSTEM

*Pin-pointing the Problem*

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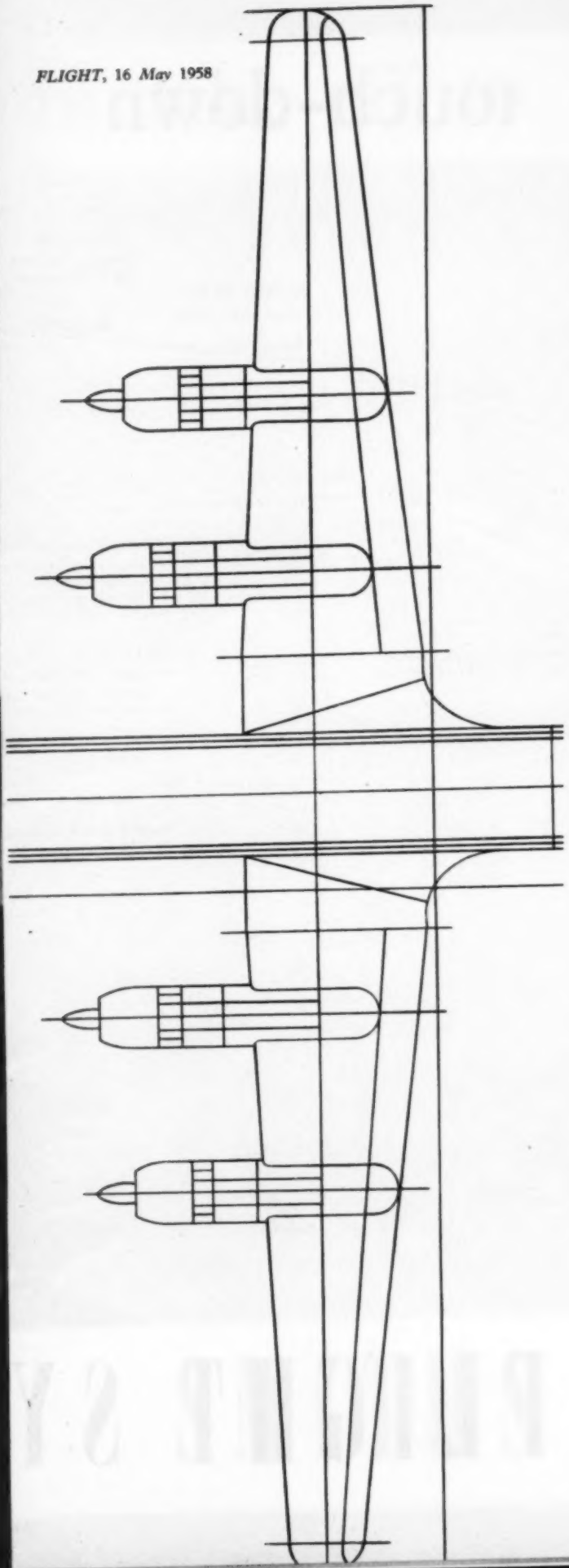
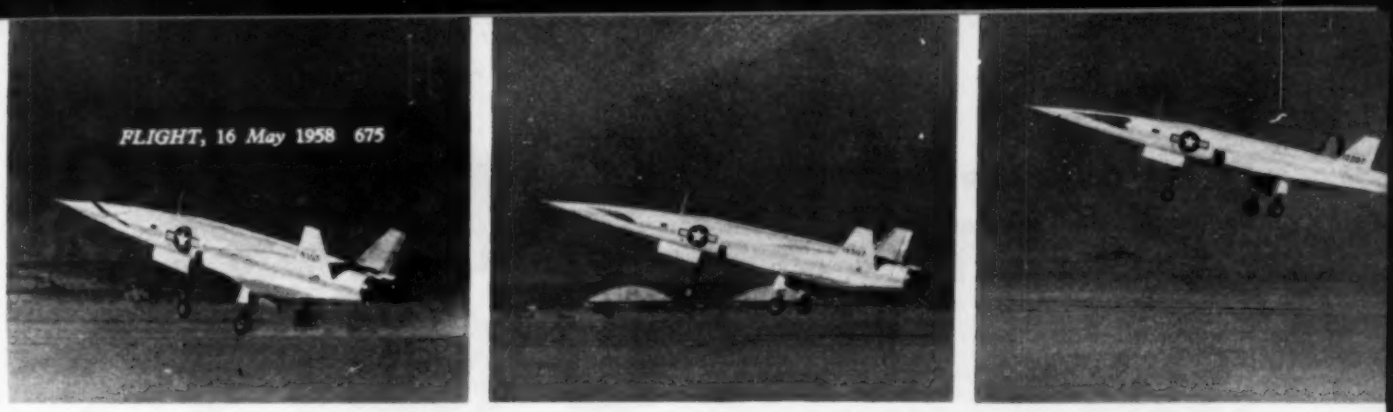




*Three tense moments in the fully automatic, 200 m.p.h. touch-down of one of the North American X-10 unmanned research vehicles. Its automatic round out system was designed by Autonetics and reduces a descent at 65ft/sec at 500ft to about 4ft/sec at touchdown.*

# PRECISION APPROACH

## *Next Step: Automatic Touch-down*

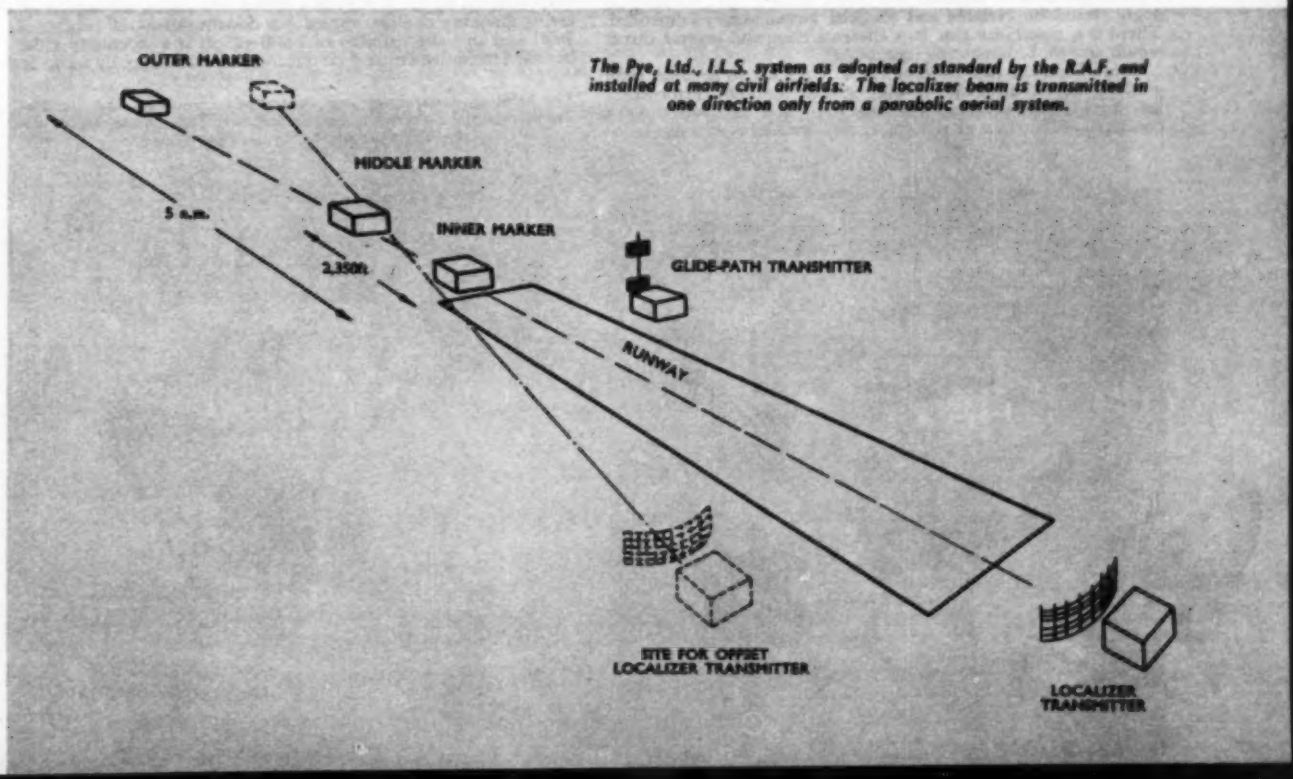
THERE is no doubt that the development of a reliable and suitably simple automatic-landing system for civil aircraft is one of the major missing links in the road to true all-weather operation by civil airlines. Automatic approaches are now routine, but a break-off height of about 200ft is still mandatory. This is not to say that a successful touch-down and ground run have not or cannot be achieved with the present combinations of I.L.S., autopilot and approach coupler, but it is a "hands-off and blind faith" technique of which the engineers do not wholly approve.

To make automatic landings routine, some way must be found of guaranteeing accurate azimuth guidance at the final stage and of accomplishing a satisfactory round-out. Azimuth guidance less critical than that of the final stages of the I.L.S. localizer is needed; and the whole system must be tied-in with autopilot characteristics suited to the required precision of manœuvre. Since automatic landing postulates occasional touch-downs in zero visibility, the automatic phase should be continued through the landing run and at least up to the point of clearing the runway. Automatic throttle, braking system and ground steering control are therefore also required. Throughout this time the pilot must be able to ascertain beyond all reasonable doubt and be confident that he will in fact touch down at the right point and be moving in the right direction.

If, as at present, the touch-down must be completed under manual control a certain finite time must be allowed for the pilot to make the transition from instrument to visual flight. He must positively recognize the visual references (usually patterns of approach lights up to 1,000 yd from the threshold), correct any errors in attitude and lateral position and then make the actual touch-down. Recent researches into this process have shown that the time allowances, translated into terms of critical or break-off height, cannot well be reduced below 150ft and that there must be 500 yd slant visibility. Even this leaves little or no room for mistakes. With D.M.E.-type aids such as BABS/Rebecca, these limits have to be doubled.

The accuracy of an instrument approach can, of course, be very greatly increased by the use of a Zero Reader flight director or one of the integrated instrument groups, either under manual control or coupled to the autopilot, but this tends to improve the position at the present break-off height rather than reduce the break-off height itself. It seems that the only way of bridging the gap between present break-off height and touch-down is to make this whole phase fully automatic.

Several methods have been tested both in Britain and the U.S.A. For some years the Blind Landing Experimental Unit at Martlesham Heath, and at R.A.E. Bedford, have been working with magnetic leader cables buried in the ground either side of the runway and extending some 1,500 yd beyond the threshold. These give a signal proportional to lateral displacement from the centre-line to an accuracy of five feet and provide directional information between the break-off point of an automatic I.L.S. approach and the beginning of the ground run. The reduction in rate of descent from about 12ft/sec on a three-degree I.L.S.




*The Pye, Ltd., I.L.S. system as adopted as standard by the R.A.F. and installed at many civil airfields. The localizer beam is transmitted in one direction only from a parabolic aerial system.*

## PRECISION APPROACH . . .

glide-path and less than 4ft/sec required at touchdown has been achieved with the assistance of a Standard Telephones STR.30 radar altimeter specially modified to give very accurate indications at heights below 60ft. The B.L.E.U. system has been demonstrated at Bedford with a Canberra approaching at about 130 kt and, though few details are available, results are known to have been good. Indications of correct working and fail-safe devices have been incorporated.

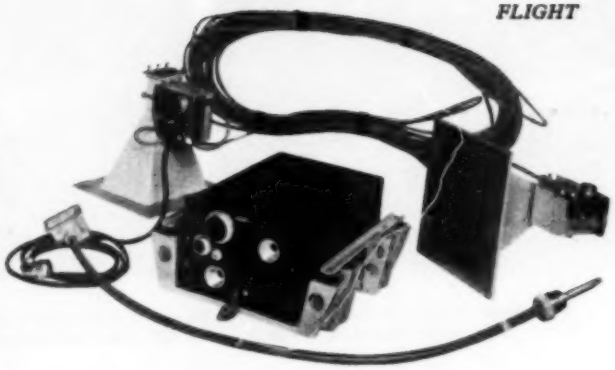
Some thought is also being directed in Britain towards the possibility of producing a visual picture in the cockpit by which the pilot might make a manual touch-down without actual sight of the ground. The electronic problems are considerable, but from the psychological point of view such a method is rather more attractive. The Pathway guidance system now being incorporated in the U.S. Navy ANIP, described on page 678, might prove adaptable, though its use in a blind landing mode has not been mentioned.

Bell Aircraft Corporation last year announced an automatic landing system designed for the U.S. Navy, and claimed that more than 1,200 successful automatic landings had been made in all weathers with aircraft ranging in size and performance from Dakotas to an F3D Skyknight. It is based on a radar which tracks the aircraft from a "gate" position and passes information on its progress to a computer. The relationship of the aircraft to a theoretical glide-path is calculated and radio command signals passed to the autopilot. Meanwhile, throttles are controlled by the Safe Flight Instrument Corporation Autopower device which senses wing lift and sets power to maintain a constant lift/drag ratio. Autopower also compensates for ground effect (the pilots found such compensation very difficult to achieve). Little round-out is apparently attempted, but the system is designed to compensate for the pitching of a carrier deck in rough seas. Trials were carried out at several airfields and on a carrier.

The Autonetics division of North American have developed an automatic landing system (as distinct from the "beeper" command landing of Regulus I and II test vehicles) for the X-10 unmanned research vehicle. It seems to concentrate mainly on producing correct round-out beginning at any height below 500ft. More than 400 landings in both manned and unmanned aircraft of varying performance have been achieved and coupling with either I.L.S. or P.A.R. are offered. In the case of the X-10, a 10 deg glide-path was chosen and sink rate reduced from 65ft/sec (4,200ft/min) at about 500ft to less than 5ft/sec at touch-down. Radar altimeter and normal accelerometer signals were combined and passed to an integrater which produced pitch command signals for the autopilot. Touch-down speed of the X-10 is in the region of 200 m.p.h., but landings were made on open dry-lake beds where centre-line and actual touch-down point were probably not critical. About a dozen successful recoveries were made.

The Los Angeles division of North American have now received a $2,600,998 contract from Air Materiel Command for development of an automatic landing system, based on this equipment, for manned aircraft. The requirements are to be investigated and a prototype is to be installed and tested in an F-100. Glide-path angle would be variable and airspeed automatically controlled. There is a possibility that flap, undercarriage and reverse thrust would also be automatically controlled.

Short Brothers and Harland, Ltd., have for some time been working on an automatic landing system for high-performance jet aircraft and successful landings have been achieved. Work continues at Belfast. A control system including attitude references, control surface loads, servos and visual simulation of aircraft responses was displayed in the company's research department building last year.



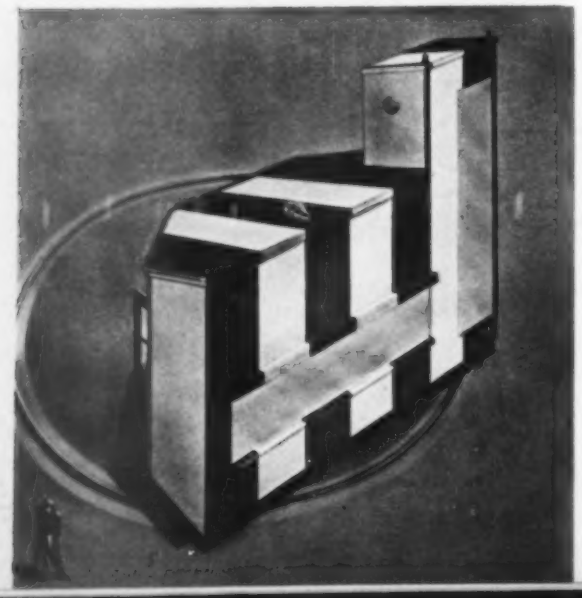
*The STR.30-B radar altimeter suitable for use from 500ft down to ground level. It is produced by Standard Telephones and Cables.*

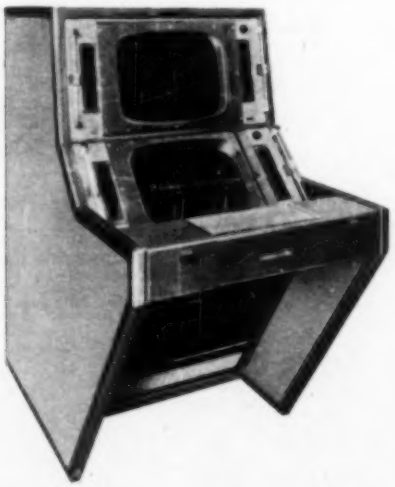
The standard civil approach aid has for some years been the Instrument Landing System which is a radio beam guidance arrangement providing separate beams for azimuth and glide-path, together with marker beacons at given points along the approach path. Localizer (azimuth) beams are transmitted in a band of V.H.F. frequencies between 108 Mc/s and 112 Mc/s, glide-path transmission is in the 300 Mc/s band and the marker beacons are all set to 75 Mc/s to be received by a universal marker beacon receiver. For glide-path and localizer, overlapping beams at 90 and 150 c/s amplitude modulation provide an equi-signal beam along the runway centreline and along a glide-path usually inclined at 2½ to 3 deg to the horizontal. A cross-pointer instrument in the cockpit shows the pilot his angular deviation from either equi-signal beam.

I.L.S. has recently also been adopted as a standard approach aid by the R.A.F.; and a system which more than meets I.C.A.O. specifications has been put into production for both military and civil use by Pye, Ltd. The localizer beam is transmitted in one direction only by a parabolic screen aerial system and full monitoring and stand-by facilities are included. If transmitted approach path or beam width change by more than 10 per cent, alarms automatically sound in the control console, which is designed for remote installation in the control tower. A reduction in transmitted power of more than 50 per cent causes automatic changeover to a second transmitter and sounding of the alarm. The parabolic aerial system concentrates the transmitted power over a sector 70 deg either side of the course line, providing greater range and less distortion than omni-directional aerials. Autopilot and approach coupler combinations are reported to give better results with the Pye I.L.S.

The BABS/Rebecca system, already briefly mentioned, has been adopted by the R.A.F. as a fighter navigation aid capable of giving guidance to allow approaches down to break-off heights of 300ft and in slant visibility of 1,000 yd. It is a secondary radar beacon system which may be interrogated effectively by up to 50

*The rotating aerial array and controller's console of the Standard Telephones SLA.3 Precision Approach Radar. The console, below, may be remotely installed in the control tower.*





aircraft at a time and presents continuously on one gauge in the cockpit a meter reading of distance from the BABS beacon and "fly left" or "fly right" signals on a scale in the lower edge of the meter. Transmission is in the 208 Mc/s to 232 Mc/s band and range at 1,000ft is 20 miles. It is made by Murphy Radio, Ltd.

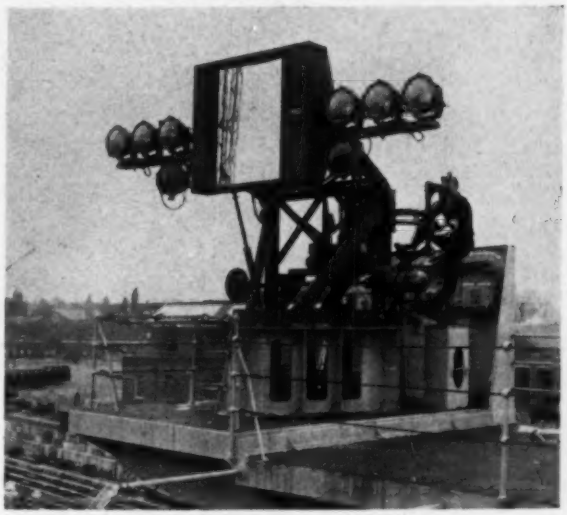
Precision approach radars have for a number of years been in large-scale use by both civil and military authorities at many of the world's airports and they can be used down to break-off heights as low as those for I.L.S. and approach coupler. Considerable technical advances have been made in miniaturizing the equipment and improving the accuracy and display, so that the first cost and size have both been somewhat reduced. Several very small radars have been prepared for use at the smaller airports. A much greater human element is involved in this method since the progress of the aircraft must be detected, appreciated and reported by an operator on the ground before the pilot will react. The time-lag, which may be up to six seconds, may on some occasions be critical.

Outstanding examples of the full-size equipment are those by Standard Telephones and Cables (SLA.3), Compagnie Française Thomson-Houston, Gilfillan, Raytheon and Telefunken. The aerials and transmitter/receivers may in most cases be mounted either in a fixed building, on a rotatable platform or in trailers, with the operating station remoted to the control tower or other convenient location. Glide-path and centreline displays are mostly grouped close together so that a single operator can easily control the whole approach operation without the need for a second man to track part of the approach.

Gilfillan also make the Quadradar, a lightweight, air-transportable unit providing both glide-path and azimuth guidance. A similar lightweight unit is made by Laboratory for Electronics and called SPAR. Both Decca Radar and Cossor produced lightweight airfield radars to a Service specification some years ago; and many of these have been sold as well to civil operators. They provide search coverage for an airfield and can also be used to give accurate azimuth guidance for precision approach to any runway. No glide-path information is available, but the "step-down" technique can successfully be used. The control console may be remoted to the control tower.

An altogether simpler system is the Ekco Electronics Airfield Approach Aid which is largely manually operated. The aircraft is located by V.H.F./D.F. mounted co-axially with the swivelling radar scanner cabinet and tracked by radar through manual adjustment of aerial elevation and azimuth. The angular alignment of the aerial is mechanically transferred to cursors on the radar-range display and shows the position of the aircraft relative to a previously marked approach path. Both homing and precision approach can thus be accomplished; and the whole equipment, operating from a standard mains voltage supply, may be set up in a small control tower or in a caravan.

Helicopter precision approaches pose rather special problems since the glide-path angle is steeper and approach speed much lower. In *Flight* for May 10, 1957, the Bendix-Decca-Bell Helicopter solution demnostrated with two Bell 47Hs was described. Decca was used with a plotting board developed from the Flight Log; and speed and height information were supplied



*The mirror landing sight aboard H.M.S. "Victorious." It is mounted on the port side of the flight deck.*

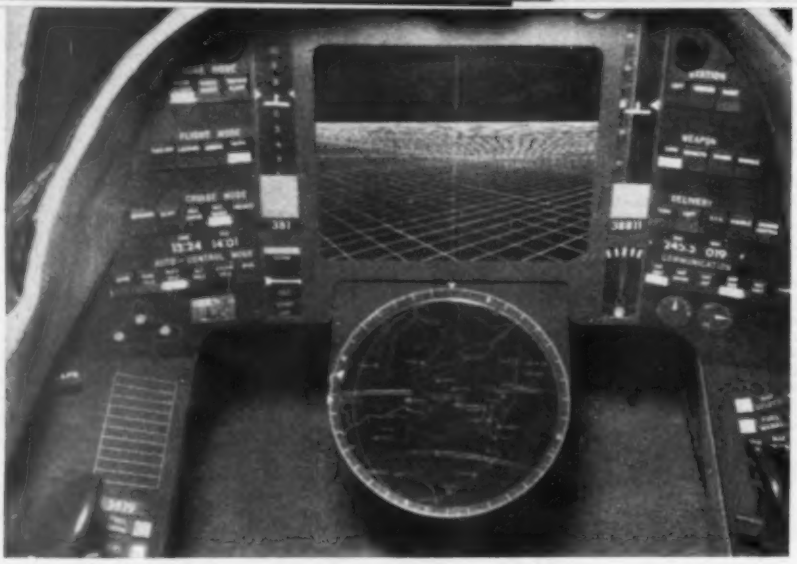
respectively by the Bendix Sonic Altimeter and Kenyon ground-speed indicator. I.L.S. was also used to make blind approaches down to 10ft. In areas of high-accuracy Decca coverage from a mobile chain in the Fort Worth area an accurate landing could be made on any Decca co-ordinate designated before take-off or in flight. Terrain obstructions were, of course, surveyed beforehand and marked on the plotting board.

B.E.A. recently demonstrated a night landing aid for their helicopters at Gatwick. It consists mainly of a double cruciform pattern of General Electric Co. lights set in the landing area, the ground being also floodlit to provide visual height reference. Visual angle-of-approach indicators were set up at the extremities of the central cross-bar. After positioning with Decca, descent and landing are made at an angle on to the centre of the light pattern, using this as a visual attitude reference.

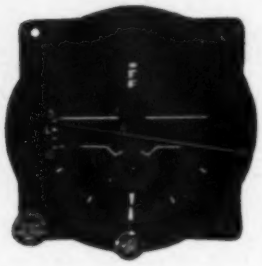
An outstanding visual approach aid is the Mirror Landing Sight, designed by the Fleet Air Arm and standardized in many navies. A spot of light is concentrated on to a concave gyro-stabilized mirror set so that when the spot appears to a pilot to be in line with a bar of lights extending either side of the mirror, the aircraft is on the correct glide-path. The system gives direct and instantaneous guidance on glide-path irrespective of ship motion; and it has contributed very considerably to a marked reduction in landing accidents at sea.

C. M. L.

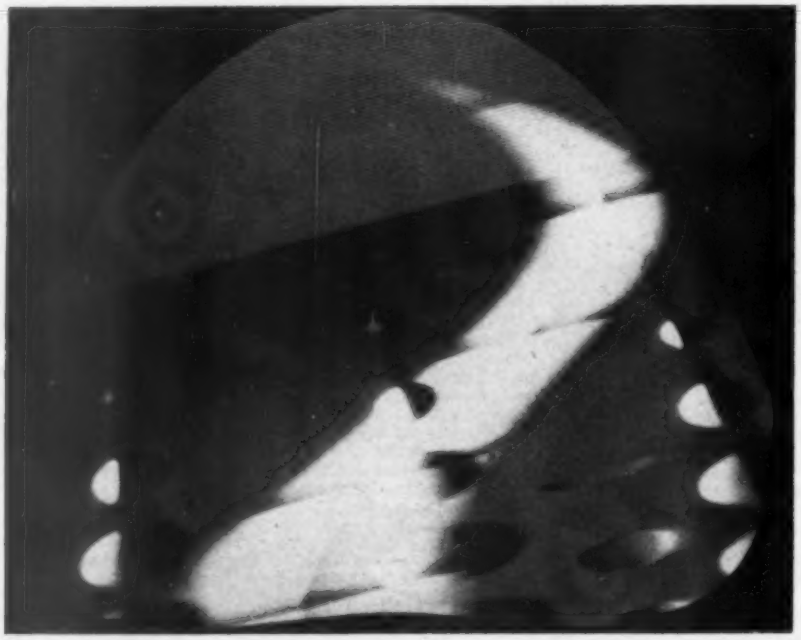
*A Westland Whirlwind of B.E.A. touches down at dusk on the pattern of General Electric lights at Gatwick. Angle-of-approach indicators are at the extremities of the main cross-bar, but are not visible because they are directed away from the camera.*



*Left, Douglas A4D interim production cockpit with ANIP. Below, British Sperry helicopter artificial horizon.*



# FLIGHT INSTRUMENTS



*Left, Pathway on a TV tube. Above, Kollsman counter altimeter. Below, American Sperry H-10 artificial horizon.*

PERHAPS the most revolutionary cockpit equipment so far developed is the Army-Navy Instrumentation Program for which Douglas El Segundo and Bell Helicopter Corporation respectively hold fixed- and rotating-wing co-ordination contracts. Flight tests of an interim system in a Lockheed T2V SeaStar began last August and information on the whole project was released to the airlines in October.

ANIP is based on a television projection system using a flat, transparent TV tube interposed between pilot and windscreen on which a grid lattice in perspective is projected to represent a theoretically flat earth below the aircraft. The grid image is constantly aligned and moved according to the signals derived from attitude and directional gyros, A.S.I. and altimeter so that the pilot has before him a realistic picture of his relationship to the earth both in attitude and movement.

Recently added is a device called Pathway, which superimposes on a flat-earth pattern a ribbon-like track along which the aircraft can be flown. Pathway can be set either to direct a desired manoeuvre or to interpret navigation signals from radio or other aids. Bell hope to fly a helicopter with ANIP next year.

The TV picture is termed a contact analogue, since it gives a picture analogous with contact (visual) flight. The device which generates the picture is called a contact analogue generator and is made by Allen B. Dumont Laboratories. Litton Industries are preparing a digital computer, with memory store, analogue-to-digital converters and redundant circuits (for later additions), which will be able to compute true airspeed, temperature and other factors and provide full information in the contact analogue. A map display will also be projected by TV on a nearly horizontal panel; and information on range and endurance as well as instructions for cruise control will be included.

Many versions of the Douglas-designed ANIP system have been illustrated; and the latest example, shown here, has a normal television screen in the panel instead of a flat tube in the windscreen. Nevertheless, Douglas mention a development in which the TV tube would be solid, not hollow, and would actually form the whole windscreen transparency. The extent of the contact analogue picture would be greatly increased in this way.

The panel being tested in the SeaStar is little more than a contact analogue, with quantitative information supplied on dials below the screen. The later version illustrated is of the interim production cockpit for the A4D Skyhawk. Here tape instruments for height, speed and engine control have been added, together with a refined version of the Douglas cockpit control-layout. The control column is a short handle on the right console, and the throttle is a hand-shaped grip to port fitted with various buttons and a trigger. See-saw switches control various aircraft functions, and digital indicaters rather than dials show radio channels, time and E.T.A. Clearly marked and integrally lit keys are depressed to select navigation and weapon control services. The circular,

## AS A FULLY-INTEGRATED WEAPON . . .

Everything connected with the flying and the operating of the ENGLISH ELECTRIC P.1B was designed and developed as a co-ordinated system. The airframe, the engines, the radar equipment, the electronic aids, the armament, the fire control devices—all were planned from the start to make the P.1B safe for its pilot, and deadly for its target.

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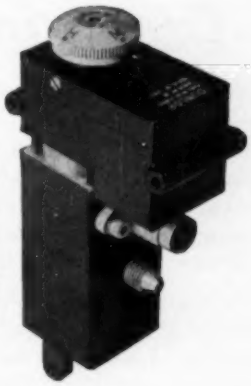
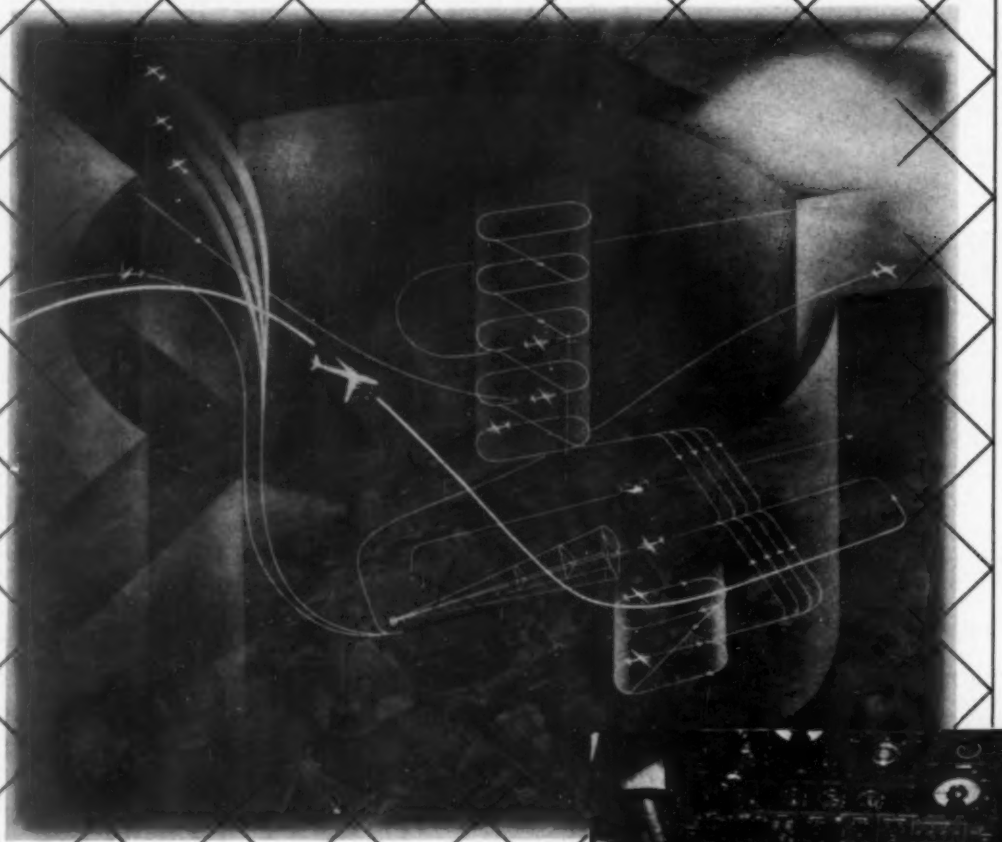
THE swift is reputed to be one of the fastest birds. The Spine-tailed species, native to India, is said to fly at 200 miles per hour. But whatever the speed of these birds, the swiftest dive or manoeuvre presents no problem. Nature provides the answer to the stresses involved. The modern jet pilot, however, requires scientifically designed protection against gravitational pull when banking and turning at high speeds. Considerable experience and research into this field has enabled Dunlop to produce Anti-G suits and valves that give adequate protection against the effects of 3 to 8 g. and help to preserve the continuous alertness necessary at sonic and supersonic speeds. They are, in fact, yet another Dunlop contribution to the needs of modern aviation.



This Anti-G valve automatically controls the air supply to the Anti-G suit. It is designed to operate at pressures from 2000 to 150 p.s.i. without use of a pressure reduction valve and is leak proof.

**ANTI-G EQUIPMENT** *for the needs of modern aviation*



*All BEA Viscounts are fitted with the Decca Navigator. Invaluable information on the requirements of jet age air traffic has been gained from over four years' operation in these aircraft.*

# Decca in the Jet Age

As more high-performance turbo-prop and turbo-jet aircraft come into service, so the problems of Air Traffic Control become more acute. For these aircraft, precise navigation is more than ever the paramount need if they are to climb and descend safely through varying levels of medium and low altitude aircraft.

The accuracy and flexibility of the Decca Navigator, which continuously pin-points the pilots exact position, ensures the efficient working of any traffic pattern, however complex. Holding areas can be designated and flown precisely at any altitude however high. No other aid can do this. Furthermore, no re-positioning of ground facilities is required if airways, terminal area procedures or holding patterns have to be changed for any reason.

The Decca Navigator can do much to reduce separation standards, so essential to economical use of air space. Indeed, it is the inherent precision and reliability of the Decca System that adds to the safety of high-performance aircraft, both in terminal areas and en route.

## THE DECCA NAVIGATOR

**THE WORLD'S MOST ACCURATE NAVIGATION SYSTEM**

THE DECCA NAVIGATOR COMPANY LIMITED LONDON

## FLIGHT INSTRUMENTS.

sloping display in this cockpit is one of several such systems shown from time to time. It is marked with an outline map of the eastern U.S.A. and beacons with their three-letter identifications. A small silhouette indicates the aircraft position and a further pattern on the map might represent weather information.

Windscreen projection of instruments, first described in *Flight* for January 8, 1954, has now been mooted by Autonetics Division of North American. Their research work began in 1954 and first flight tests have recently been made. The scheme envisages reproduction of I.L.S. cross-pointers, artificial horizon and approach speed-deviation on a cathode-ray tube of 1.5in diameter. This image would be projected through collimating lenses and reflected to the pilot's eyes from a special "combining" glass mounted on the windscreen. The glass would effectively reflect light in a narrow colour-band—green for example—so that the instrument indications would appear in green while the outside view in other colour-bands would still be clearly visible. The pilot would not have to accommodate his eye-focus to make a visual transition for touch-down after an instrument approach; neither would such features as approach lights be obscured. The combining glass can reflect a light-image of sufficient intensity to avoid the need for very high voltages in the cathode-ray tube —a difficulty with earlier projection systems. The Autonetics instrument display projecter requires only about 4,000 V instead of 20,000 V.

**Dial Instruments.** Development of flight instruments of the gyro and pressure types continues, and improvements in both performance and presentation are being incorporated as the state of the art advances.

It seems generally agreed that the best indication for the turn-and-slip instrument is a ball for slip and a needle for turn; and this has been standardized by the R.A.F. and several airlines. R. B. Pullin make many of the instruments used both in miniature and standard dial sizes. They are operated at 4,200 r.p.m. by 24 V D.C. current so that they can be effectively used after failure of the A.C. supply to the main flight instruments. A singular feature of a Russian turn-and-slip indicator seen in the Il-18 cockpit (*Flight* for April 25) was that the turn needle was calibrated for degrees of bank up to 45 deg at a speed of 500 km/hr.

Artificial horizons of various configurations are favoured in various countries, America and Czechoslovakia making use of the globe type with full freedom in pitch and roll; the Sperry H-10 is the latest example. French horizons with both flat sky-plates and drum systems for the pitch axis have been produced, an example of the latter being the SFENA type 700. Power supplies required are 115 V, 400 c/s; and the drum is marked with dotted lines denoting various degrees of pitch and is coloured to represent sky and earth.

British horizons, notably those made by Sperry and Ferranti, are A.C.-operated, erect from standstill in 20 sec, and have automatic levelling and compensation for turn errors; many may be operated from either A.C. or D.C. supplies with automatic changeover. Sperry have produced an air-driven horizon conforming to the standard British requirement for ±85 deg freedom in pitch and full freedom in roll. They have also produced both air-driven and electric horizons for helicopters, providing an aircraft silhouette which is adjustable to show level flight at various fuselage pitch angles.

Pressure-operated instruments, such as altimeters, A.S.I.s, vertical speed indicators and Machmeters are reaching a difficult stage because of the increasing range of pressures over which they are now required to indicate. Altimeter presentations have been altered to give completely unambiguous indications of height, for example by the incorporation of a striped "flag" to warn of heights below 10,000ft. Veeder counters are also being introduced for indication of thousands of feet, leaving a single needle to show hundreds only. In an effort to increase the range of the pressure-capsule instrument, Kelvin Hughes have produced the powered altimeter which senses the very small displacements of the capsules at heights above 50,000ft and amplifies electrical pick-off signals to operate a counter motor. Heights up to 100,000ft can be measured and rates of change of height of 10,000ft/min can be accurately followed.

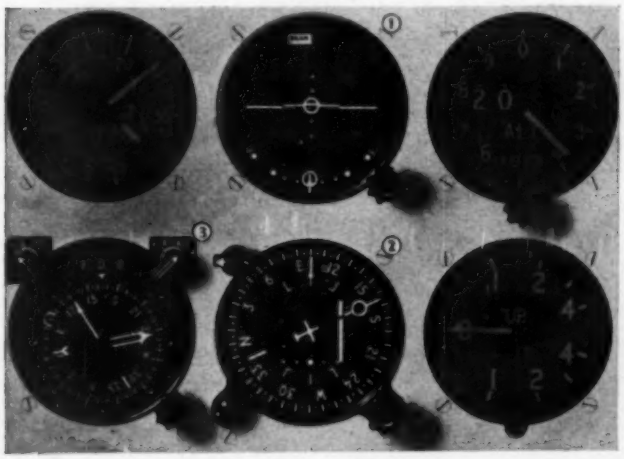
The Research Laboratory of Servomechanisms, Inc., has made a study of the feasibility of using an ion chamber for obtaining altitude indications in regions where atmospheric pressure is far too low for normal pressure-capsules. Their engineers maintain that the most satisfactory method of applying the principle is to include the chamber in a simple oscillatory circuit from which the output voltage frequency varies as an approximately linear function of the logarithm of air density. The wave form appears as a clean saw-tooth, with voltage amplitudes varying between about 200 V near zero frequency to about 20 V at the high frequencies.

Vertical-speed measurement by pressure capsules limits the range of indication to a maximum of approximately 6,000ft/min. The need to measure accurately the very high climb and dive rates of modern aircraft has led to the suggested use of rate gyros for this purpose. It has also been suggested that inertial-quality intergrating gyros might be used to produce steady and accurate indications of rates of descent from radar altimeter signals to assist automatic landing systems in achieving the critical round-out phase of the landing.

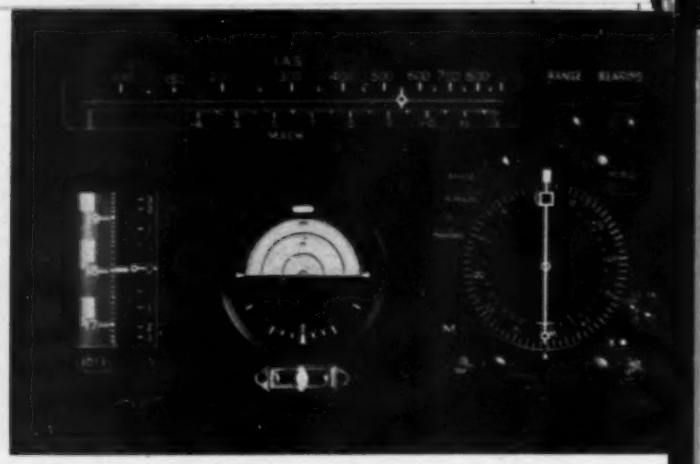
**Director Instruments.** The work load on the pilot in both civil and military flying is increasing to such an extent, as is also the performance of aircraft, that more and more instrument lay-outs are being based on director instruments and increasing efforts are being made to combine information from several sources on one dial. Working from the general foundation by Sperry with the Zero Reader Flight Director, several companies have produced single director dials or groups of such instruments designed also for operation as an integral part of an autopilot. All of these are basically similar in that they combine attitude information with steering directions on one dial, while information on compass and radio-aid heading, with suitable presentation of relationship to a desired beacon radial, are displayed on another dial. A third dial or control is mostly used for setting selected headings for the directors.

The type of integrated flight instrument groups described above have been designed to provide the pilot with much the same commands as are supplied to present-day commercial autopilots with approach couplers and heading- and height-locks. They work in conjunction with standard receivers for I.L.S., V.O.R. and associated marker beacons operating in the standard V.H.F. radio frequencies. In most cases they are considered as integral portions of the related autopilots. Thus the Smiths Aircraft Instruments Flight System is related to the S.E.P.2 autopilot; the Sperry Integrated Instrument System to the SP-30; the Collins Radio Company FD-105 to the AP-101; the Bendix flight-director system to the PB-20 or PB-10. Lear, Inc., have developed the Lear Integrated Flight Equipment, which provides attitude and displacement information and a compass card on one of the two dials. In contrast with usual practice, the aircraft silhouette of the attitude display moves against a fixed horizon in accordance with Lear's own Nafli (natural flight) precepts. Their "human engineering" team consider this a more natural presentation. Russian horizons also have this presentation.

A French director instrument is the Chombard Synthetizer produced by SFENA. Here, the director function is provided by the aircraft silhouette, which moves as well as the horizon bar of



*The Smiths Flight System, left, as fitted in the Comet 4. Main dials are the director horizon, beam compass and course selector. The A.S.I. has maximum and actual airspeed needles and Mach scale while the altimeter has veeder counters. Below, the Sperry integrated instrument system shown illuminated by special integral lighting.*



*The Kelvin Hughes Flight Data System (right) for the Royal Air Force. Roller-blind and tape instruments are driven from the Brown Master Reference Gyro and an air data computer. The detail views of the navigation display show (anti-clockwise) roller-blind positions for I.L.S., Tacan homing and offset homing to selected points.*

## FLIGHT INSTRUMENTS...

the gyro horizon. The pilot flies his aircraft to maintain the bar and silhouette constantly aligned with each other. Since both silhouette and bar move there is no continuous indication of aircraft attitude relative to the ground, but in case of instrument malfunction the silhouette can be locked and the system reverts to a normal horizon function. The director function can be coupled either to a barometric height capsule or to a gyro compass heading set on a compass card in the instrument frame. A scale allows setting of a given aircraft pitch angle; and a selector can be used to set heading lock, I.L.S. blue left and right and approach. The main advantage claimed for the Chombard instrument is that it provides a director instrument which closely resembles the standard artificial horizon and is as easy to use as that instrument.

The director function has also been applied to instruments intended specifically for military applications. A particular example is the Lear attitude indicator for the AJB-3 toss-bombing system. Here a globe horizon element, coloured to represent sky and earth on either side of an "equator" marked in degrees of compass heading, provides heading and attitude indication, while the correct g-load required throughout the bombing manoeuvre is noted on a vertical scale beside the dial, together with an indication of the g-load actually being exerted. Since a remote gyro reference is used with this system, the attitude indicator is fully free and can be used throughout a roll-off-the-top. The AJB-3 was described in *Flight* for January 3.

**Moving-tape Instruments.** It was a development programme initiated at the behest of the British Services which, some years ago, led to what has been described as the greatest advance yet in flight instrumentation. During this research two leading tenets were evolved, namely, that the conventional dial instrument was totally outmoded for high-performance aircraft and that so many aircraft systems required both attitude and heading gyro information that a single gyro reference should be provided to serve them all. Following the second of these principles, a central source of data on the atmosphere through which the aircraft was flying was also developed.

The first tangible results of this thinking were widely publicized in America during 1956, some time after information had been handed over from Britain. Initial facts about the British Roller Blind Attitude Indicator and Master Reference Gyro, respectively made by Kelvin Hughes and S. G. Brown, were released in England in the autumn of 1956 and early in 1957. It was not until the S.B.A.C. display last year that the full Kelvin Hughes Flight Data System was first publicly shown, by which time it had already been flying successfully in research aircraft for some time. It is illustrated above in its various modes of operation.

Information previously supplied by A.S.I., Machmeter, altimeter and V.S.I. are presented on two tape systems, that for height and vertical speed being aligned vertically and that for airspeed and Mach number horizontally. In the first case a logarithmically marked tape shows height against a fixed index mark while a moving pointer shows vertical speed against an adjacent scale marked logarithmically from 0 to 4,000ft/min. Inset below these is a window for the barometric pressure setting. A fixed logarithmic airspeed scale in the horizontal display is traversed by a pointer and the corresponding Mach number is aligned with this pointer by a moving tape. Information for these tape displays is derived from static and dynamic pressure- and temperature-sensing probes, the signals from which are interpreted and corrected in an electro-mechanical computer to provide barometric height, rate of change of height, indicated airspeed, Mach number and true airspeed. The capsules are fitted with force-balance sensing systems giving a very accurate linear output as a mechanical rotation. Probe-position error correction is introduced electro-mechanically. Similar methods are used in computing rate of change of height. True airspeed is calculated, but is not presented on the basic display.

Attitude and gyro heading information are provided by the Master Reference Gyro, which has full freedom through 360 deg of roll and pitch. It is described in greater detail in the appropriate section of this review. Electrical signals are passed to the roller-blind attitude indicator and to the compass card on the navigation display, as well as being available for flight-director indications and other aircraft services, such as radar and camera stabilization. The blind of the attitude indicator is divided into black and white sections, denoting sky and ground, the straight junction of which represents the standard horizon bar. The whole assembly is rotated for roll indication. Nadir and zenith in vertical dive and climb are shown on the blind by stars, the longest tail of which will always point towards the nearest horizon as soon as the aircraft departs by a few degrees from the vertical. The compass also will then indicate the heading of the nearest horizon. A steering dot is superimposed on the attitude display for flight-director purposes; and a ball slip-indicator is mounted immediately below the dial, which is edge-lit.

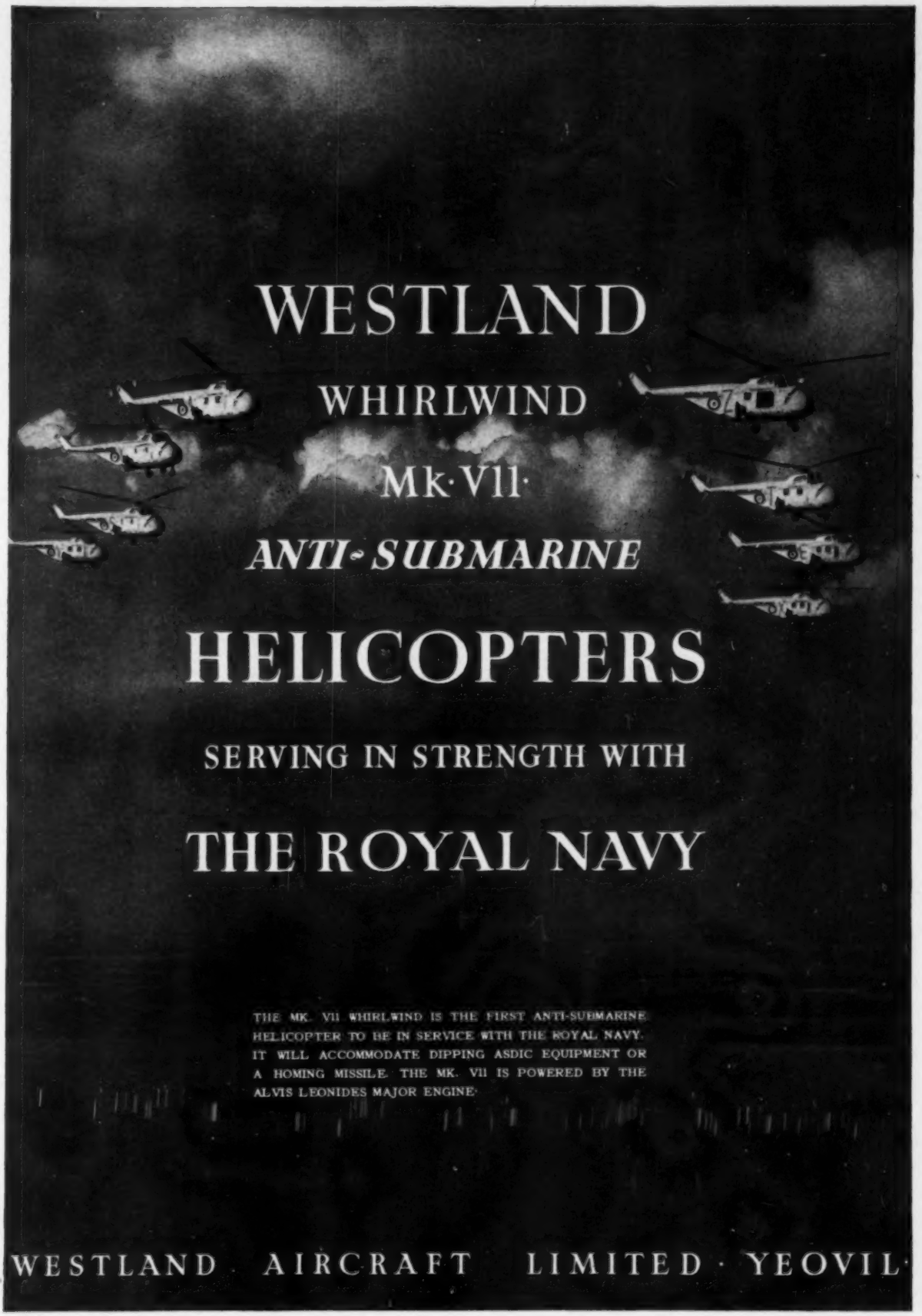
In the compass mode the navigation display behaves much like the standard gyro-magnetic compass, using a detecting element specially designed for combination with the master reference gyro. Dot-and-cross enunciator and desired heading bar are provided. The centre of the display is another roller blind and, for I.L.S. approaches, a horizontal deviation scale appears. Tramline pointer for azimuth and single pointer for glide-path indications appear in conventional I.L.S. form, while I.L.S. displacement signals are also fed through the attitude element to operate the steering dot on the attitude indicator. When using Tacan, the navigation display blind carries a line which indicates the compass bearing from aircraft to beacon. Behind this a series of arcs marked in ranges show the range of the beacon against the ring in the centre of the dial. Exact range is indicated in a small window. The fourth navigation display is similar to that for Tacan, but the bearing and range of a given point from the beacon are manually set in the windows above the display; and an offset computer will then calculate and pass to the roller blind the homing course and distance to that point.

The Flight Data System panel measures approximately 1ft 4in wide by 10in high; and the whole system—including panel, offset computer, compass amplifier, air data computer and compass detector—weighs about 66 lb. Power supplies are about 800 V.A. at 115 V, 3-phase, 400 c/s and 28 V D.C.

In aircraft fitted with such an integrated instrument system some stand-by instruments are necessary. In most cases these include a conventional miniature A.C./D.C. artificial horizon fitted with a ball slip-indicator; a magnetic compass, probably of the Kelvin Hughes E2.A or E2.B type; and stand-by A.S.I. and altimeter.

Sperry have also produced a roller-blind attitude indicator. The principle of operation is broadly similar to that of the Kelvin Hughes indicator, and the dial markings are almost identical. It uses a remote attitude gyro with fast-erection device and allows full freedom in roll and pitch. The dial-face is edge-lit and may be mounted flush with a sloping panel if required.

American tape-indicator developments, one of which is shown on page 681, follow broadly the same lines as in Britain. Manufacturers there have, however, concentrated to some extent on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# BEAVERS AND OTTERS AROUND THE WORLD

De Havilland Civil and Military Beavers and Otters are operating in 58 different countries on 7 continents, and from Pole to Pole

## Where Beavers and Otters are operating

| | | | | |
|---|---|---|---|---|
| Alaska | Colombia | Haiti | Libya | Sierra Leone |
| Algeria | Cuba | Honduras | Malaya | South Africa |
| Antarctica | Dominican Republic | India | Mexico | Syria |
| Argentina | Dutch New Guinea | Indonesia | New Zealand | The Philippines |
| Australia | Ecuador | Iran | Norway | Turkey |
| Bolivia | Egypt | Italy | Pakistan | United Kingdom |
| Brazil | El Salvador | Japan | Panama | United States |
| British New Guinea | Falkland Islands | Kenya | Paraguay | Uruguay |
| Cambodia | Finland | Korea | Peru | Venezuela |
| Canada | Formosa | Laos | Puerto Rico | West Africa |
| Chile | Greenland | Lebanon | Rhodesia | Yugoslavia |
| | Guatemala | Liberia | Saudi Arabia | |

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## FLIGHT INSTRUMENTS . . .

producing a layout in which heading information is as far as possible displayed along a vertical centre-line projected over the whole panel. Similarly, speed, attitude and height information is related to a horizontal datum line across the panel. To this end both speed and height tapes are vertically aligned, with speed on one side of the attitude display and height on the other. The navigation display is at the foot of the panel, in some cases inclined at a desk-top angle. Airways maps are also included in some versions of which pictures have appeared.

Eclipse Pioneer division of Bendix Corporation hope to have improved versions of U.S.A.F.-developed vertical tape units ready for the F-105 and F-106A early next year. Servomechanisms, Inc., are working on tape displays for height and vertical speed. Lear, Inc., are also involved in complete panels, but none of these systems is yet known to have reached as advanced a stage of production as the British system—particularly where master gyros are concerned. One system has been flown in two F-102As and other applications include the F-105, F-101, B-58 and T-38.

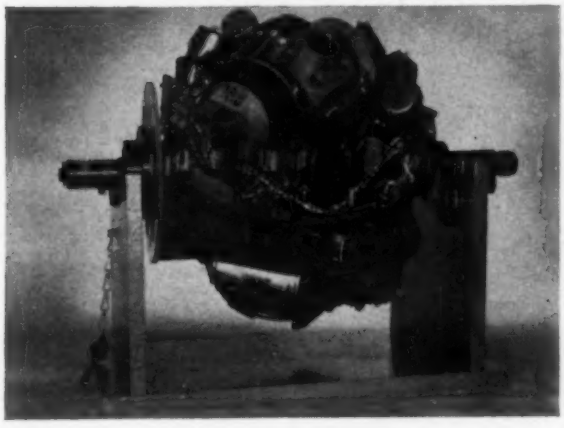
**Gyro References.** Though now accepted as an economical and rational way of providing gyro references for all normal aircraft systems and appreciated as the only way of providing true all-attitude flight instrumentation, the master gyro is still a relatively rare bird. A British Service requirement for such equipment was issued by R.A.E. in 1950 and the first unit was test-flown in October 1954. Called the Master Reference Gyro, it was produced by S. G. Brown, Ltd., and until relatively recently it had remained the only unit to be based on just two gyros. Lear, Minneapolis Honeywell and Bendix worked for some time on three-gyro units although Lear and Bendix have now begun publicizing two-gyro units which should be ready for production fairly soon. The S. G. Brown M.R.G. Mk 1 is now standard equipment in all the latest R.A.F. and Fleet Air Arm fighters and in very-high-speed research aircraft. Many foreign air forces have shown keen interest. With a view to further development, S. G. Brown have signed an agreement with Bosch Arma in America which will allow them to take advantage of Bosch gyro flotation techniques.

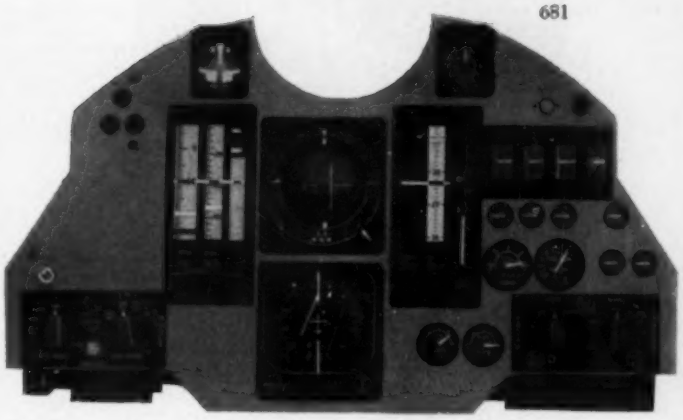
The increased accuracy of inertial-quality gyros could greatly improve the M.R.G.'s performance for air, sea and land uses. In aircraft it might well enable the M.R.G. to provide the extremely precise heading information needed to make full use of Doppler radar. The gyros at present used in the M.R.G. Mk 1 have a specified random wander rate of $\pm\frac{1}{4}$ deg/min and the accuracy of the vertical datum of the platform in unaccelerated flight is $\pm\frac{1}{2}$ deg. In accordance with standard Service requirements the M.R.G. is ready for use 20 sec after switching on. It was described in detail in *Flight* for April 12, 1957.

A recent innovation in gyros is the Sperry Rotorace, which offers a considerable improvement in wander rate over gyros at present used for normal heading or vertical indications, but without the extreme complexity and cost of floated inertial-quality gyros. Some years ago heading gyros were expected to have a random drift of up to 15 deg/hr; and the Bendix Polar Path reduced this to about 2 deg/hr. Rotorace at present offers the remarkably low drift of 0.25 deg/hr, though further development might reduce this to as little as 0.05 deg/hr. PanAm, S.A.S. and K.L.M. are reported to be evaluating Rotorace fitted retrospectively in the Sperry C-11 compass systems of their DC-7s.

The principle of Rotorace is that the housings of the gimbal bearings are continuously rotated at about 20 r.p.m. in opposite directions, the direction of rotation being periodically reversed.

*Master Reference Gyro, by S. G. Brown, Ltd., shown uncased.*





*U.S.A.F. instrument panel, probably destined for F-102, F-105 and F-106.*

In this way the random torques produced by inevitable minor imperfections in the bearings themselves are largely cancelled out, because no flaw remains in a critical location for any length of time. The cost of a Rotorace is about one-fifth that of a floated gyro of inertial quality.

Rotorace has also been incorporated in a lightweight, two-gyro stable platform being produced for the U.S.A.F. One gyro monitors azimuth and roll and the other azimuth and pitch. The axes of the two rotors are coupled to remain always 90 deg apart, so that the azimuth drift of the system is never more than that of one of the gyros. Random drift of the horizontal and directional plane is 0.25 deg/hr and drift of the vertical axis is 0.1 deg/min. Compass flux-valve and coupler are included in the 26 lb unit, and signals for aircraft equipment as well as flight instruments are provided.

**Air Data Systems.** The Kelvin Hughes Flight Data System, described earlier, includes an electro-mechanical air data computer. Other systems of this type have been developed, particularly by Elliott Brothers (London), Ltd., and Louis Newmark, Ltd., in Britain and by Bendix, AiResearch, Servomechanisms, Inc., and Kollsman Instruments Corp. in the U.S.A. They are flexible in that each specific installation would be matched to the requirements of a particular aircraft.

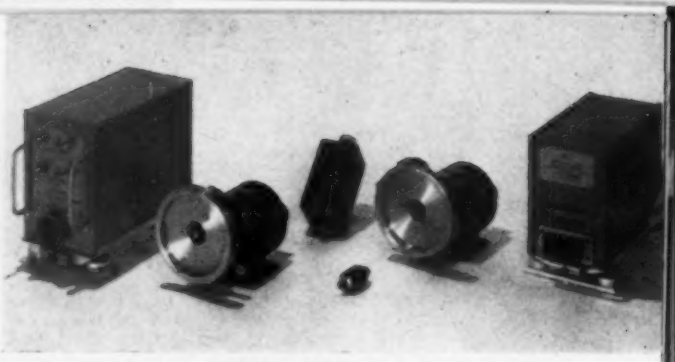
At the S.B.A.C. Show last year, Elliott Brothers (London) first exhibited their system which, from transducers providing static, pitot-static and temperature information, produces indications of I.A.S., Mach number, height, rate of climb, and true airspeed. The computer includes transistorized and magnetic amplifiers, differentials, cams and servo-operated gear boxes. Position-error corrections may be incorporated as a function of Mach number introduced at the pitot and static transducers. From 80 kt to 150 kt, presentation is linear, becoming logarithmic from 150 kt to 900 kt. Mach number range is from 0.3 to 3.0 and heights from −1,000ft to 100,000ft. Pressure settings between 800 and 1,100 millibars can be manually introduced. T.A.S. and rate of climb indications are respectively between 200 and 1,600 kt and up to 3,000ft/min. With four-channel outputs the computer weighs 20 lb and requires a power supply of 160 W at 115 V, 400 c/s. Elliott have also developed moving-tape indicators.

The Louis Newmark unit weighs 12 lb and is intended as a source of height, airspeed and Mach number signals for controlling or varying the response of an autopilot. The unit has two capsules, one measuring static pressure and the other the difference between dynamic and static pressure, their movements being converted to shaft rotations and servo-followed. Each drives a number of potentiometers, a clutched potentiometer and the common Mach computer. Standard A.C. and D.C. supplies are required.

The Bendix air data computer, made by the Eclipse Pioneer division, senses total and static pressure, temperature and angle of attack, computes them and passes them through a converter to a digital counter T.A.S. indicator, a Mach and A.S.I. dial and, as electrical signals, to other user systems. It applies corrections as required; and the computer, converter and compensater together weigh about 45 lb.

The AiResearch system also helps with engine control and includes engine-intake sensing. Information is provided for the powered control system, autopilot, bombing and navigation computers, flight instruments and engine-intake control. Gloster Technical Developments Division are making this system under licence.

Servomechanisms have adopted a "building block" layout using series of standard plug-in units which can be combined into a suitable installation for most aircraft and easily maintained in the field by unit replacement. Additional quantities such as target co-ordinates, angular and linear acceleration, aircraft weight and skin temperature, wind direction, engine r.p.m. and burner tem-



***Left, the new Sperry Rotorace gyro, in which the gimbal bearings are rotated continuously to reduce drastically random drift caused by minute bearing imperfections. Above, Safe Flight Instrument Corporation's Autopower with two throttle servos.***

## FLIGHT INSTRUMENTS . . .

perature can be fed into the computing elements. Manual setting, fixed probes and moving vanes drive transducers, from which plug-in units (now in production) calculate height, ram ratio, Mach number, angle of attack, angle of yaw, T.A.S., air density, rocket jump angle, missile jump angle and dynamic pressure. Fire-, camera-, engine-, navigation- and flight-control can be provided. Standard A.C. and D.C. power supplies are needed.

The newly formed Electronic Controls Division of General Controls Company has been awarded a U.S.A.F. contract for the design of an advanced air data computer for the century-series fighters.

The only air data system so far announced specifically for civil airliners is the Kollsman Integrated Flight Instrument System—in many ways a misleading designation. It is designed principally to correct normally sensed air data by electrically cross-checking the various quantities before they reach the panel instruments. In case of a failure, direct indications from the sensing elements are automatically restored. Dial instruments show height, speed, Mach number, outside air temperature and true airspeed, the latter on a digital counter. The system operates over the 0 to 50,000ft and 0 to 450 kt ranges and has been accepted by Douglas for the DC-8.

**Wing Sensing Devices.** For years pilots have relied on their A.S.I. for guidance on the behaviour of their aircraft. Reliable A.S.I.s were developed relatively soon after the Wright brothers began flying and, by adding a number of knots to the approach speed ("five for a wife and two for each child" has come to be regarded as a good insurance in difficult conditions) a pilot might compensate effectively for rough air, or high landing weight. But the stall is related to angle of attack and a knowledge of this quantity offers far better guidance on the performance of the wing at any moment. Various sensing devices have been produced to show angle of attack, almost all requiring some form of vane pivoted by airflow relative to wing or fuselage. Because the pivots were extremely difficult to seal efficiently against weather, and because it was hard to find an area of undistorted flow on the airframe, little progress was made until relatively recently. The pilots, too, found it unnatural to fly by angle of attack rather than airspeed.

Mechanical difficulties have now been largely overcome and many stall-warning and lift-sensing devices are on the market for both light and heavy aircraft. Landings on aircraft carriers have always required the slowest possible approach and precise control of speed with little or no time for the pilot to study his A.S.I. closely. Aural indication of I.A.S., fed into the earphones as an intermittent or constant tone, was therefore developed by Kelvin Hughes and is standard in Fleet Air Arm fighters. In addition, this company has produced the stall-warning detector Type C, which consists of a spring-loaded flag mounted above the wing in an area where flow breaks away near the stall. When this occurs the airflow ceases to hold the flag parallel to the line of flow and allows it to turn normal to it. A hermetically sealed magnetic switch is then closed to activate the warning system, whether this be an audio tone, warning light or a stick-shaker.

An extension of this system is the Kelvin Hughes Audio Incidence System, which compares pressure measured at a point under the wing with total head pressure in the normal pitot head. This ratio is a function of the angle of attack; and audio signals proportional to it are fed to the earphones as either intermittent or continuous tones, representing respectively angles of attack below or above an optimum value. A visual indication can also be provided if required. Pressure senser and sound generator are mounted in a single sealed case and weigh 4.5 lb.

In order to make the transition from traditional reliance on an A.S.I. to use of an angle-of-attack indicator more natural for the pilot, Kollsman Instrument Corporation has produced a combined instrument on which speed is indicated in the normal way while an angle-of-attack scale moves round the edge of the dial so that the ruling value lies opposite the A.S.I. needle. The moving scale is marked simply with A, B and C, respectively indicating the angles of attack for best approach, best cruise and stall.

Stall-warning indicators have become very popular for light and business aircraft in the U.S.A. A small vane protruding through the lower part of the leading edge of the wing is generally set so that near the stall it flips over and closes a switch. Horns or lights are used as indicators.

Two further devices, both made by the Safe Flight Instrument Corporation, have gained wide acceptance by both airline and private operators. The first of these is called Speed Control and, in effect, shows the pilot on a small instrument whether he is obtaining the best lift from his wing. A small vane protrudes through the skin under the leading edge and operates a transducer, the electrical signals from which are passed to a computer. Here the signals are corrected according to a mechanical input from a shaft recording flap position and also according to a longitudinal accelerometer signal directly related to the power-drag condition of the aircraft. The integrated signal is displayed as a needle deflection against a scale showing "slow," "fast" or "best" approach speed. Speed Control can be used during the approach, on take-off when the best climb is required, or during slow-speed flying. It gives a true indication of wing performance in all aircraft configurations and it is free from the lag suffered by conventional A.S.I.s. Over 40,000 Speed Controls have been sold.

The second Safe Flight device is called Autopower. Signals from the Speed Control are passed through a lift coupler to a servo amplifier and thence to servos in the throttle control cables, allowing the lift signals to be directly applied to the engine power setting, so causing the aircraft to maintain its best speed for approach or slow flying. Autopower may be fitted in conjunction with (but quite separately from) a standard autopilot; and this was in fact done in a DC-3 when making automatic landings with the Bell Aircraft automatic landing system. It was found that the human pilot could not control the throttles accurately enough to avoid touching down too fast or slowly when under automatic glide-path guidance. Speed Control and Autopower placed the aircraft at the touch-down position at exactly the right speed for a successful landing. Autopower may be set to maintain an aircraft at specified percentages of its Vsl. During the Bell trials the initial value set was 1.6 Vsl, and reduced to 1.4 Vsl shortly before touch-down. At about 23,000 lb weight, the DC-3 first approached at 95 kt and then at 84 kt. When full flap was applied just before touch-down, the speed decreased to 80 kt. Ground effect was automatically compensated for by Autopower.

The big jets will probably require some form of instrument to indicate early during the take-off run whether sufficient acceleration is being developed for unsticking in the expected distance. The Services have tackled this problem by painting a white marker a given distance from the threshold of each runway. The crews calculate, for their particular loading, what speed they should have reached when passing this line. Civil operators have proposed an instrument which would indicate acceleration against some fiducial mark and show instantly how the take-off was progressing. Canadian Marconi exhibited such a system, called the Take-off Monitor, three years ago. It continually indicates the relation between airspeed and acceleration throughout the take-off run, showing clearly whether take-off speed will be reached in the normal distance.

C. M. L.

***The Safe Flight Speed Control indicator for mounting on the cockpit coaming. It is 2¾in wide.***

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The Gloster Javelin's engines can be removed, new ones installed easily, in two hours. All its other vital parts are also supremely get-at-able. This ease of servicing is one of the many things that have earned this all-weather fighter the affection of the R.A.F. squadrons with which it is now on duty.

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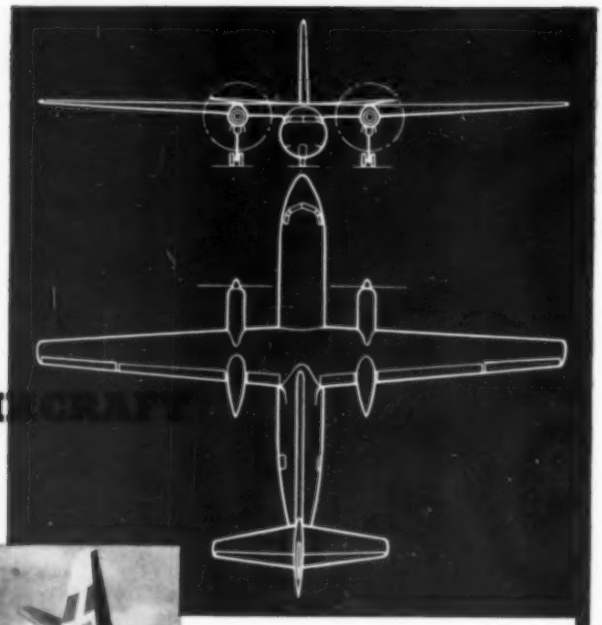

# FOR EVERY TYPE OF AIRCRAFT

In common with many other branchline feeder aircraft, the Fokker Friendship is equipped with Kelvin Hughes Instruments like those shown here. The range of Kelvin Hughes flight, navigation and engine instruments covers the needs of this and every other type of aircraft. The information they provide is confidently trusted by airmen of many nations flying civil, military and experimental types.
Further particulars of these and other instruments are available on request.

*Synchroscope*

*Turn & Slip Indicator*

*Rate of Climb Indicator*

*Sensitive Altimeter*

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# Straight and Level

JUST before the end of the last war, the nations of the world—with one notable exception—signed the Chicago Convention. The offspring of this agreement was the International Civil Aviation Organization, which became an agency of the United Nations. The air transport operating countries of the world—with (repeat) one exception—bound themselves to operate to I.C.A.O.'s standards, and to conform to its recommended practices. In I.C.A.O. the nations painstakingly formulated a kind of supra-national government to foster the orderly development of international air transport. It has worked like a charm, in spite of many conflicts, because the nations wanted it to work.

Then, after 13 years, up pops the exception. Confident in her fine new aircraft (designed and operated to standards about which no one outside Russia knows a thing), the U.S.S.R. offers to exchange traffic rights with the outside world.

This is all very well, and I am hopeful that nothing but political good will come out of air commerce with Russia. As Mr. Kruschev told Lord Douglas, aeroplanes should carry passengers rather than bombs. But we shall save ourselves a lot of trouble if we insist that Russia agrees to abide by the provisions of the Convention, which have served the rest of the civilized world so well these past 13 years.

● I hear that the prototype de Havilland Mosquito, W4050, progenitor of a most noble and glorious breed of aeroplane, is to find eternal rest in the actual place of its birth—Salisbury Hall, London Colney, Hertfordshire.

This, the moated 17th-century house built by Charles II for Nell Gwynne, was where de Havilland secretly designed and built the first D.H.98 Mosquito in the dark days of 1940. After the war, the Hall was for a time the headquarters of the D.H. Technical School; it lay neglected until 1954, when it was bought and restored—with great care and taste—by its present owner, Capt. W. Goldsmith, Royal Marines. The aircraft will, he hopes, be on view to the public during the summer.

I can think of no happier a memorial to the immortal Mossie.

● Have you ever noticed how, in order to heighten dramatic effect, some writers resort to a little pure invention? Last week I was reading of a visit to a steelworks, wherein the author described the "roaring of the molten steel" as it flowed from a furnace tapping for casting into pig. I've never heard molten steel make more noise than a frying egg.

My morning paper recently called the piece of de Havilland IRBM airframe which one can see from the Barnet bypass "a gleaming steel cylinder." I wonder why? As far as I can see, the obvious material to use is aluminium alloy.

● At a quick first glance there appears to be nothing unusual about this El Al Britannia 313, seen taxying in at New York Idlewild.

But to the M.T.C.A. air traffic controller who happened to be walking near

B.E.A.'s maintenance base at London Airport at ten o'clock on the morning of Friday, May 2, there *was* something unusual about the fact that a wheel was lying on the grass at the east end of No. 5 runway.

He promptly reported it; and B.E.A. confirmed with Bristol's service engineers at London Airport their suspicions that the wheel belonged to a Britannia. Somewhere, unknown to its pilot, a Britannia was airborne—if not actually about to land—with one wheel missing.

There began perhaps the fastest piece of emergency aviation detective work on record. Within the hour the following things were done. B.O.A.C. checked whether any of their Britannias had been out of London the previous night. As it so happened, none had. London Control confirmed that El Al Britannia 4X-AGC had taken off for New York at 02.30 and was presumably within two or three hours of its E.T.A. at New York. Bristol Aircraft at Filton identified the serial number as belonging to a wheel fitted to 4X-AGC. London Control alerted Idlewild, who advised the El Al captain—who had just been diverted to Boston—to land at Idlewild where better emergency facilities existed. Newsreel and television photographers turned out in full force at Idlewild, only to be disappointed (?) by a perfect landing.

Capt. Zwi Tohar (who, incidentally, flew a Britannia on its non-stop New York - Tel Aviv record last December) said: "I noticed nothing on take-off or landing." Perhaps he would have if he hadn't had four-wheel bogies.

● The recent disclosure that an order for 70 Sea Hawks was cancelled only one year after the introduction of the angled deck into service with the Royal Navy gave a clear idea of the accident-reduction value of this invention. It must have saved the Navy a cool £3,000, in fact, because a grateful Admiralty awarded the two men primarily responsible £1,500 apiece.

As has been said before, the angled deck is the sort of thing that now—after it has been invented—seems so obvious. Why didn't anyone think of it before? One reason why one person at least didn't think of a mere angled deck was that he had bigger ideas. The deck would not just be fixed at an angle—it would swivel round so that aircraft could land into wind, along the deck, even if the ship were steaming cross-wind.

And that's only half the story. Not only would the deck rotate, turntable fashion, but it would go up and down, lift fashion, too. Thus, instead of the aircraft approaching along a glide-path down to the deck, the aircraft would fly past straight and level, as the deck rose up to meet it. You've probably guessed that the aircraft had no wheels and the deck was made of rubber.

● Peter Masefield, reviewing Oliver Stewart's book *Danger in the Air*, wrote last week in the *Manchester Guardian*: "The only dogma in aviation is that there can be no dogma."

The prototype of this aphorism is, of course: "The only thing you learn from history is that you learn nothing from history." Which, I think, is 99 per cent true. But my first reaction to Peter Masefield's *bons mots* was that they are themselves dogmatic. Then I looked up the word dogma just to make sure, applied it to aviation, and decided that he is right. The business is teeming with people who make downright assertions based upon insufficient facts.

● According to *American Aviation*, more than 20 per cent of the employees—employees, not just scientific and engineering staff—of Aerojet-General hold science degrees. As this famous rocket-propulsion firm employs approximately 11,500 people, I calculate their boffins to number something in excess of 2,300. Could someone tell me how many degree-men we have working on British rocket motors? Oh yes, I forgot; this sort of figure is a military secret in Britain. And I almost forgot to say that Aerojet-General is not even the biggest American rocket company.

● I like the remark of the air traffic forecaster who said: "I can never meet another air traffic forecaster without laughing."

ROGER BACON

*The first B.O.A.C. Comet 4 to take shape in de Havilland's "second-source" Comet production line at Chester is seen here. Chester, D.H.'s main aircraft assembly factory, is sharing with Hatfield the Comet production programme. B.O.A.C.'s Comet plans are discussed below.*

# CIVIL AVIATION

## B.O.A.C.'s COMET PLANS

ALTHOUGH B.O.A.C. are, quite understandably, maintaining a commercial-security blackout on their plans for trans-atlantic jet operation, it is quite clear that they are making determined efforts to meet the threat of PanAm 707 competition. During the last two weeks the two de Havilland Comet 2Es which the Corporation has had in operation since September 1957 diverted their Avon RA.29 development flights to the London-Gander route. A total of 11 such flights (via Keflavik) was due to be completed by today, May 16.

These flights—the first transatlantic jet airliner proving-flights to be made—were in anticipation of the possibility that B.O.A.C. will introduce Comet 4s into transatlantic service if and when PanAm do likewise with their 707s. B.O.A.C.'s American rival will not yet say whether, as reports suggest, they will start Boeing 707-120 services between New York and London on November 1. This is not surprising, since the achievement of such a schedule with the 707 depends upon a satisfactory amount of crew-training and route-proving, not to mention certification (due now in August) and—perhaps the biggest uncertainty—acceptance by New York of the 707's noise.

According to reports last week, which B.O.A.C. did not deny, the Corporation hopes to begin weekly Comet 4 Atlantic services on December 1, with daily services from January 1. This means that Comets will probably not now begin to serve the Commonwealth routes (see *Flight* of March 28) until 1960.

This may be prestige-chasing, and B.O.A.C.'s better judgement may have been to put the Comet 4 into service on to the routes for which it was meant; but it so happens that, in the present fares situation, it is the jet which will get the North Atlantic traffic.

## THE THIRD MAN

IT is unusual for airline pilots, who like to regard themselves as professional men, to strike. It is even more unusual when 263 of them employed by a trunk-route airline ground that airline for 84 days (to date), with no reconciliation in sight.

Yet this has happened in the case of Western Air Lines, the American domestic carrier which operates 6,500 miles of route over a network based on Los Angeles, California.

The reason for the strike goes much deeper than an employer's refusal to increase pay: in actual fact, W.A.L. pilots are the fifth highest paid in America, receiving an average annual salary equivalent to £4,560. Their remuneration is exceeded only by that of the pilots of T.W.A. (highest average annual salary, £4,970), U.A.L., Northwest, and American. Western's pilots receive more than their opposite numbers in Braniff, Eastern, Capital, Continental, Delta, and Northeast (the last-named being the lowest paid, at an average of £3,740).

The fuss—which could well put Western out of business—is really about the controversial "third man" issue. The pilots feel that there will be fewer piloting jobs to go round when the more highly productive turbine transports come into operation. But they feel also that these aircraft, thanks to the turbine engine, will be simpler to operate, and that they can easily be managed without a flight engineer. They want the third man to be a pilot, with flight-engineering qualifications.

But according to U.S. law a flight engineer must be included in the crew of every transport aircraft weighing more than 80,000 lb, and the position of the flight engineer is, therefore, legally unassailable. But in any case the engineers feel—and this is a reasonable point of view—that turbine transports will *not* be simpler from the engineering standpoint, but will in fact be more complex.

It is understood that three of America's major carriers, Pan American, T.W.A. and American, have all acceded to this point of view, and that they have contracted to keep the professional flight engineer on their payrolls.

It appears that America's airline pilots, through their club, the American Air Line Pilots Association, are fighting a losing battle. The Western strike is a test-case; it is easy to understand the reasons for their pilots' objections, and to feel sympathy for their proposition that the third man should be a pilot with flight-engineering qualifications. Many pilots regard flight engineers as "passengers," cluttering up already overcrowded cockpits, and doing jobs which the pilots feel they could just as easily and safely do themselves.

It could still happen that A.L.P.A. will ground the whole of America's air transport industry; but, even assuming that they win, the airlines will still be grounded by a strike of flight engineers which would almost certainly ensue.

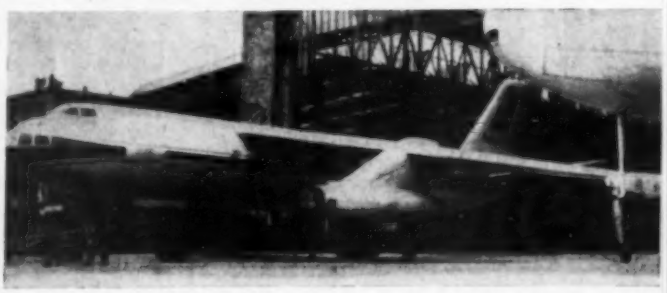
So it looks very much as though the *status quo* will continue and the third man will be a professional flight engineer. And whatever happens in America is likely to provide a precedent for the rest of the world.

## RUSSIAN WEDGE IN ARAB DOOR

THOUGH only the sparsest details are available, it is now clear that the two airlines of the United Arab Republic—Syrian Airways and Misrair—are to be merged into one airline. "Final talks" to settle details of the amalgamation have, according to an Egyptian broadcast last week, begun in Cairo.

Even without the merger, it has been fairly obvious for some time that these two airlines were unlikely to do their future airliner-shopping in the West. The economic influence of the U.S.S.R. in the United Arab Republic is now so strong that the possibility of Tu-104s being ordered is highly likely. Indeed, unofficial reports in Egyptian newspapers last week suggested that three Tu-104s have, in fact, now been ordered.

If this is true, it marks the first occasion on which the Russian aircraft industry has captured a market hitherto the potential preserve of the West. Misrair operate two Viscounts, with two more on order; Syrian Airways operate DC-4s and DC-3s.



*Emerging from the factory at Dresden, where it will shortly begin flight tests, is East Germany's new four-jet short-range jet airliner, the B.B.152. It is the first original transport aircraft to come from either East or West Germany since the war. The most recent details appeared in "Flight" for March 14. Note the bicycle main gear, the rear truck of which permits the aircraft to "pray" on take-off.*

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CIVIL AVIATION . . .

# Financing Britain's Airliners

TECHNICAL QUALITY ALONE DOES NOT SELL NEW TRANSPORTS

By J. M. RAMSDEN

**THE recent decision by a Commonwealth airline, T.E.A.L., to allow its better technical judgment of a British aircraft be swayed in favour of American equipment highlighted a big problem: how can British manufacturers match the financing offered by their American competitors?**

AMERICA, the citadel of hire-purchase, is a nation built on credit. The American attitude to money is fundamentally different from the British: money is something you can buy, like any other commodity, and it can be bought cheaply. You can walk down Madison Avenue and see how money is merchandized, in the full American meaning of the word. Some of the big banks have eye-catching window-displays, like pretty girls ice-skating, to lure custom. The window-shopper is "cordially invited" to step inside to discuss his "personal problems."

In contrast is the solid, reserved respectability of the City of London. The old lady of Threadneedle Street has never been lavish with her sterling; but today, in the fight to preserve the pound's value in an inflationary world, she is tighter with her money than she has ever been before.

This contrast is felt by British civil aircraft manufacturers wherever they compete with Americans for business in the markets of the world. It is felt also by other exporters, but particularly so by those trying to sell to the world's airlines. There is no other class of industrial consumer whose volume of business (and therefore demand for new equipment) is increasing so fast, yet whose profitability (one per cent of revenues in 1957) is so small.

## The Need for Equipment

Whatever the reason for their low profits, and no matter how self-inflicted they may be, the airlines still need new equipment. Their problem is how to pay for it. The manufacturer who can offer the easiest terms of payment is therefore the one who gets the business nowadays. Technical competition is being accentuated, if not outweighed, by financial competition. The airlines want credit—long-term credit—at cheap interest rates, and America can give them these things.

The terms which Boeing, Convair, Douglas and Lockheed are now offering are quite remarkable. A few years ago the airlines put down a substantial pre-payment, made progress payments during manufacture, and paid the balance on delivery. The raising of capital was usually the customer's responsibility, as in any other normal business deal. Now such financing arrangements are rare indeed. Gradually, as airline money has become tighter, and as the first fine careless rapture of equipment-buying has passed, the manufacturers have had to devise easier financing arrangements to get the business. Today contracts may be signed with American manufacturers which require no downpayments (perhaps, as a sign of good faith, a small deposit); no progress payments; and credit terms extending from seven to ten years from the signing of the contract, and at 4 per cent interest.

Sometimes, in their eagerness to sell, American firms offer extra come-ons like: (1) Hire-charter for a year or two to see if the customer likes the aeroplanes. If he does, the hire fees will be regarded as part of the capital payment. (2) Offers to buy back the new equipment at market price after use. (3) Offers to finance, or at any rate underwrite, the purchase from the manufacturer's own resources (e.g., the contract between General Dynamics Corp. and Capital Airlines for nine Convair 880s, plus an option on six). (4) Part-exchange of new equipment for old.

The last-named inducement, which of course appeals greatly to an industry becoming more and more concerned about the re-sale value of existing fleets, is a comparatively recent innovation. Pioneered by Lockheed, it is a sales-promoting ploy *par excellence*. Trade-in offers for old equipment, though routine in the American motor-car industry, is new in the airliner business. The trading-in of airliners is a bitter challenge to British manufacturers, who cannot even afford to match the "normal" financial competition, let alone to indulge in gimmick-deals of this kind.

How indeed can the Americans afford it? It is tempting to answer that this is their problem, or to suggest (as was done in a recent extraordinary outburst in Parliament) that American airliner business tactics are "unfair" or "cut-throat"—if not actually part of some sinister plot, perhaps backed by the State Department, to put British aircraft manufacturers out of business. Nothing could be further from the truth, or more unworthy. The truth is that British manufacturers are being beaten not technically, but in a straight financial contest with a combatant who can say this to a customer:—

*"We don't want a downpayment. We don't want progress payments, at least not from you. We can arrange through the U.S. Export-Import Bank for the necessary credit to be advanced to you by one or more of the American commercial banks. This credit can be extended over the useful competitive life of your new aeroplanes, and it will be advanced at a rate of four per cent. You start paying when your new aeroplanes start earning. . . ."*

If this fails, the inducements previously listed are then suggested.

It should not be supposed that British firms and the City banks are not straining their commercial resources and risks to the utmost to meet this competition. Air Finance, Ltd., the financial consortium of leading British aircraft firms and City banks formed in 1953 to ensure that Britain's technical lead was sold, have done £40 millions' worth of business to date. Their loans are largely guaranteed (up to 90 per cent) by the Board of Trade, through the Export Credits Guarantee Department. But Air Finance cannot get round two obstacles: (1) The fact that the E.C.G.D. cannot (under the Berne agreement) cover credit beyond five years; and (2) high interest charges.

The high British bank-rate is the more serious obstacle to the successful exporting of British airliners. It stands at 6 per cent (7 per cent until a few weeks ago). Commercial banks usually add between one and two per cent to this, so that the best rate which can be offered may amount to 7 or 8 per cent.

It requires no knowledge of accountancy to see what this kind of interest—double that which the Americans can offer—can do to an airline's costs. Whether airlines regard interest as a direct operating cost or not, it is in fact an aircraft standing charge—like depreciation and insurance. If it is too high it will wipe out profits. B.O.A.C., for example, in their recently completed financial year, had an operating deficit of about £0.75 million; yet their total deficit was £2.75 million—*£2 million being interest on capital*. Even if the Corporation had managed to break even on its operations, it would still have lost £2 millions. Likewise B.E.A.'s interest charges are very high: they have gone up about 140 per cent since 1950, and will probably go up by the same amount over the next seven or eight years.

Interest is not, surprisingly enough, included in S.B.A.C. or A.T.A. aircraft operating cost methods. So even if a British airliner does appear to be cheaper to operate according to these formulæ than an American competitor, this apparent advantage can be reversed by interest charges. Indeed an airline with high interest commitments can easily find the increased earning power of its new equipment vitiated by interest on the capital borrowed to pay for that new equipment.

## Trading in Old for New

A final word about the practice of trading-in old airliners for new. American firms can presumably afford to do this because the cost of buying back old fleets is probably less than the cost of slowing down gigantic production machines. One can only guess the cost of running a production machine such as that now building Electras or 707s; perhaps it is £1 million a week. Whatever the amount, the Britannia, Comet 4 or Vanguard production machines, by contrast, can only be one-quarter as costly to run. Furthermore, the risk of having to scrap as a dead-loss bought-back piston fleets is not as great in America as in Britain. There is always the mighty M.A.T.S. to be maintained at full strength, with spares and new (or refurbished) aircraft. There are also the large civil "irregular" carriers whose business is expanding (see last week's *Flight*), and who do not yet aspire to turbines. It is also quite likely that the cost of trading-in is actually passed back to the customer—though he need not know this—in the price of the new aircraft.

It is difficult enough for British manufacturers to break into a market for 20 years dominated technically by America, especially when the technical lead formerly enjoyed by the British is now diminished. It becomes even more difficult—and the recent *cri de coeur* in de Havilland's annual report emphasized this—when such overwhelming financial competition is superimposed.

These are hard and gloomy facts, and they cannot be swept under the carpet with complacent expectations that everything will turn out right in the end. There is hope that the special Government committee now studying the problem will, before too much more business is lost, recognize that the aircraft industry of this country must—in an age of diminished military contracts—live largely on civil exports; and that aircraft exports embody, as does nothing else, the engineering and technical expertize by which Britain must earn its living in the world.

*This is Westland's scheme for a London heliport, the public inquiry into which was due to be in progress today in London. Its position relative to Battersea power station is clearly seen: the Thames-side strip in the foreground measures 125ft by 50ft; the large building beyond the 200ft wide dispersal area is a proposed new factory. See item below, which discusses also the Rotorports, Ltd., scheme.*

## CIVIL AVIATION . . .

### LONDON HELIPORT COMPETITION

DISCONTENT about British civil helicopter progress was voiced recently by Lord Douglas, who said in as many words that, unless Government support is more fully forthcoming, the nation may as well decide to drop its promising helicopters—i.e., the Fairey Rotodyne, the Westland Westminster and their developments—altogether. He added that "penny packets" of Government support merely squandered the taxpayers' money.

This point of view fairly summarizes the technical development status of British commercial helicopters today. And discontent with the continuing official neglect of helicopter operations was also in the news last week.

As recorded in *Flight* of March 7, two private concerns are now competing for the honours of constructing and operating a heliport in London. The capital has had no scheduled helicopter services, and no permanent heliport, since the South Bank site was closed to B.E.A. in 1955.

The two organizations concerned are Westland Aircraft, Ltd., and Rotorports, Ltd. To recapitulate their plans: Westland propose to develop a permanent site on the Thames near Battersea power station (see illustration); Rotorports, Ltd., propose—for their first stage—a temporary 100ft-square floating platform off the Albert Embankment opposite the Tate Gallery. Each organization has submitted its plans to the authorities for approval; last week, in the County Hall, Westminster, the Ministry of Housing and Local Government public inquiry into Rotorports' plans was heard. Today, May 16, the Westland proposals were due to be heard, also in the County Hall.

Objections to the Rotorports plan—which, as a floating site, represents only the first experimental stage towards a permanent riverside site—came at last week's inquiry from Westland, the London County Council, the Westminster Hospital, and various concerns with premises near the site. The findings of this public inquiry, and that which was due to follow today into the competing scheme, will be awaited with the greatest interest by Londoners, and by those who hope to see official encouragement of British helicopter operations.

### VETO ON THE Tu-104

WHEN the Tu-104 was last week required to land the Moscow Arts Theatre party at Stansted instead of at London Airport, it was assumed that an official ban on the Russian jet's use of L.A.P. is now in force. In fact, because the noise of the aircraft is considered by the U.K. authorities to be unacceptably high (the Russians accept this, and are taking steps to reduce it), the Tu-104 will not for the time being be accepted at London—except in special diplomatic circumstances.

Thus the Tu-104, without any Russian political umbrage having been caused at all, is at the moment banned from the airports of the West's three main capitals—New York, London and Paris.

## BREVITIES

LATEST customer in the DC-8 order book is Iberia, who have ordered two for delivery in 1960 and taken an option on a third. DC-8 orders now stand at 140. S.A.S. may increase their option by two, giving seven on order and five on option.

* * *

A provisional Certificate of Airworthiness has been awarded to the Dart Herald which has now completed 70 hr flying.

* * *

The Federation of Malaya has become a member of I.C.A.O.; there are now 72 member States.

* * *

Aerlinte Eireann and Austrian Airlines have been admitted as active members of I.A.T.A. This brings the total number of active members to 75 and the total membership to 84.

* * *

Two Fairchild F-27 Friendships are now flying at Hagerstown. The third—due to be delivered to West Coast Airlines in June—should fly shortly.

* * *

While alterations at Airways Terminal are carried out B.O.A.C.'s Cargo Department has moved to 14 Dilke Street, Chelsea Embarkment, London, S.W.3.

* * *

The first production Caravelle should fly this month and two more production aircraft before the end of the year. Sud-Aviation have scheduled for production of 75 aircraft, and will manufacture up to three per month in the first half of 1960 and five aircraft a month after that if necessary. Components and equipment are supplied by 260 companies, French, British and American.

* * *

Work on sub assemblies of the twenty-eighth Electra has begun at Lockheed's California Division. Three aircraft are now flying, three more are complete and 11 are on the assembly line. Another aircraft should fly this month. The Electra has been undergoing icing trials in the Anchorage area. It was shown that 3½in of ice on the wing and tailplane leading-edges could be dissipated in between 8 sec and 13 sec.

Air Charter have received a contract from the Dutch distributors of Rover cars to fly at least 300 Rovers and Land Rovers annually from Southend to Rotterdam.

* * *

One of the two prototype Fokker Friendships left Schiphol on April 27 for a demonstration tour of South America. The aircraft is fitted with pylon tanks and an auxiliary fuselage tank. Stops will include Brasilia and the 13,190ft altitude airfield at La Paz.

* * *

Figures quoted by the British Travel and Holidays Association show that 64,700 overseas visitors arrived in Britain during March—15 per cent more than last year. Excluding those from the Commonwealth, 53 per cent of all March visitors arrived by air.

* * *

B.O.A.C. are to discontinue the four times weekly service between Miami and Nassau on June 3, it was announced in the U.S. by B.O.A.C.'s manager, Mr. R. H. Trench Thompson. The route has not proved profitable.

* * *

A new weather ship, *Weather Reporter*, is to take her place this month in the chain of five European vessels stationed between Europe and North America. The new ship, which has a crew of 50, replaces *Weather Explorer*.

* * *

Five features dealing with London Airport will be shown in B.B.C. Children's Television at approximately monthly intervals this summer. The series is called *Skyport Story* and the individual programmes "Coming and Going," "Live Freights," "Servicing the Giants," "Aircrew" and "Control Tower." The first programme will be screened next Tuesday, May 20.

* * *

The Canadian Government Board of Inquiry into the loss of the T.C.A. North Star on December 9, 1956, concluded that the accident occurred as the probable result of icing or turbulence while the aircraft was flying on three engines. They said that it was not possible to determine why the aircraft was flying low enough for it to strike Mount Slesse.

# CLUB AND GLIDING NEWS

*The new Saab 91.D version of the Safir, described in column 2 below.*

WINNER of the Quennevais Trophy for the best performance at the International Rally at Jersey last week-end was H. B. Showell in an Auster Aiglet. The Miles Gemini flown by F. Emery of Lancashire Aero Club won the *Concours d'Elegance*; and the sealed arrival-time prize went to M. Lalanne of Aero Club de Normandie. A total of 44 aircraft had been entered for the rally, but bad weather prevented eight of them arriving.

THIS year's winner of the flying scholarship awarded by the Women's Junior Air Corps is Miss Patricia Attridge, a 20-year-old secretary from Putney who has been a member of the Corps for five years. Flying tests for the seven final candidates took place at Croydon on Saturday, May 3, and interviews were held the following morning.

A DEVELOPMENT of the Saab 91B and 91C Safir fitted with a lighter engine has received its type certificate from the Royal Swedish Board of Civil Aviation. Designated Saab 91D, it is powered by a four-cylinder Lycoming 0-360-A1A of 180 h.p. in place of the six-cylinder, 190 h.p. Lycoming of the earlier versions. A new constant-speed propeller and a more powerful generator are installed.

The aircraft is fitted with new wheel brakes, of Goodyear single-disc type, while the main exterior differences are the modified air intake and propeller spinner.

Empty weight has been reduced by 100 lb, and performance is practically unchanged at the same useful load, in spite of the 10 h.p. reduction in engine power. Maximum take-off weight is 2,657 lb; other data include top speed, 165 m.p.h.; cruising speed, 146 m.p.h.; economical cruise, 136 m.p.h.; and range, 620 miles.

FOLLOWING the recent annual general meeting of the Plymouth Aero Club, the committee of the club now comprises Sir Arthur Hollely (president), D. P. Fitzgerald (chairman), L. C. Blamey, W. G. Boylett, R. H. Cove, D. H. Cundy, R. B. Holman, T. Nicholls and T. Szparowski; with *ex-officio* members W. H. W. Lucas (secretary and manager), Lt-Cdr. A. W. Watson (R.N. Engineering College) and F/L. A. McLeish (No. 19 Group, R.A.F.). The club fleet now consists of four Tiger Moths, one Chipmunk, one Auster, one Messenger and one Gemini, plus two R. N. Tigers on loan for Naval training.

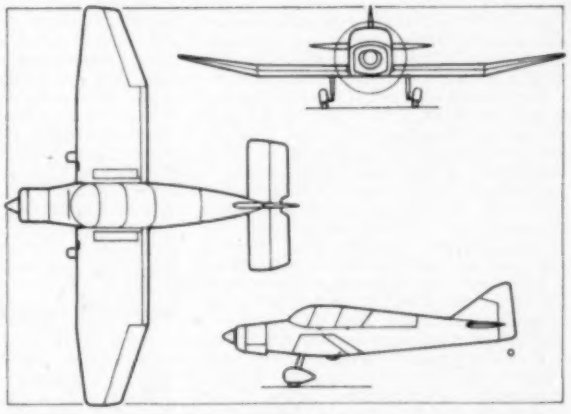
A TOTAL of 22 sailplanes have been entered for the annual championships of the R.A.F. Gliding and Soaring Association, which start at South Cerney tomorrow (May 17) and continue until May 27. Approximately 175 Association members will participate, as pilots, crews and officials, and the organization will be modelled on last year's B.G.A. nationals. Among the competing pilots will be G/C. R. R. Goodbody, chairman of the R.A.F.G.S.A., and W/C. N. W. Kearon, O.B.E., deputy chairman.

## FIVE-SEATER JODEL

AMONG the foreign sports aircraft demonstrated at the recent Hanover Air Show was the French Jodel D.117 two-seater produced by Lucien Querey's Société Aéronautique Normande of Bernay. Chief pilot of this company since the beginning of this year is Léon Biancotto, well-known in this country for his aerobatic performances in Lockheed Trophy contests at Baginton, and he was the pilot of the attractive example F-BHGE on view at Hanover. In an interview there with Ken Owen of *Flight*, Biancotto gave details of the 4/5-seater Jodel D.140 Musketeer, scheduled to begin flight tests this month.

As indicated by the model photograph and the g.a. drawing, the Musketeer is a direct development of the D.117. Its power-plant is a 180 h.p. Lycoming 0-360-A2A, in place of the 90 h.p. Continental of the two-seater, and its flying weight is 2,400 lb (four persons and 220 lb of baggage, or five persons with 55 lb).

For aerobatic flight at a two-seater weight of 1,870 lb, the D.140 is designed to a factor of ten. Wing area is 194 sq ft and wing loading 12.4 lb/sq ft, cruising speed is 140 m.p.h., and endurance is six hours. Responsible for the development of the machine is Jean Delemontez, assisted by his father-in-law, M. Joly. Inclusive export price of the Musketeer, calculated at the beginning of this year, is given as 12,000 U.S. dollars (about £4,300).



*The Jodel D.140 (model, below, and g.a. drawing) is a 4/5-seater development of the two-seater D.117, seen (below right) at Hanover.*

# SERVICE AVIATION

*Admiral Sir Peter Reid, Third Sea Lord, being greeted by Mr. J. Dent, chief engineer (guided weapons) of Short Brothers and Harland, Ltd., on a recent visit to the company's Castlereagh factory. On the right is Mr. H. G. Conway, Shorts' chief engineer and deputy managing director, and just visible on the left is Mr. A. R. Harryman, production manager.*

## CONFERENCE "PROSPECT"

WITH some 350 representatives of public life as guests—from industry, professions, the other Services, trades unions, youth organizations and civic life, and including several M.P.s—the R.A.F. held a one-day conference at the Royal Empire Society on May 6 when [as we briefly reported last week] its policy, organization and views on the future were outlined. The Duke of Edinburgh was among those who attended; the Minister of Defence, Mr. Duncan Sandys, was unable to be present.

The conference followed the form taken by a similar one (called Prospect One) for senior R.A.F. officers held at Cranwell last month. Three playlets and three papers were given; in between there were discussions; and the day's proceedings were opened and closed by addresses by the Chief of the Air Staff, Marshal of the R.A.F. Sir Dermot Boyle.

In his opening remarks the C.A.S. explained why such a conference was being held: "Simply because there has been and still is great confusion in many people's minds about the rôle of the Royal Air Force both now and in the future. We feel that this confusion is bad for the country and for the Service and since we are quite clear in our minds what our responsibilities are and how we are going to meet them, we feel that nothing but good can come from telling you what we think and having the benefit of your comments and interest."

Sir Dermot emphasized that no attempt was being made to "sell" the Air Force at the expense of either of the other Services; but since the R.A.F. dealt in advanced techniques it was difficult for people to understand "what it was about" unless they were told. Reckoning itself "a worthwhile nuisance and a good investment," the R.A.F. intended to explain why. "We feel the more you know about us, the better."

Each item on the day's agenda was introduced by the V.C.A.S., Air Marshal Sir Edmund Hudleston, the first being a dramatized discussion on "the R.A.F. and U.K. defence policy." This proved to be an "investigation" by three M.P.s—on Congressional sub-committee lines—of an R.A.F. witness, A. Cdre F. E. Rosier, who is Director of Plans at Air Ministry and who also directed Exercise Prospect. What emerged from it was that the R.A.F. believes in flexibly graduated deterrents, from conventional forces to meet minor aggressions, to tactical and strategic weapons for meeting greater aggressions; and that its rôles are to maintain the deterrent, to contribute to NATO and the Baghdad Pact and SEATO, and to provide forces for imperial policing. One question raised in subsequent discussion (by the Suffragan Bishop of Maidstone) was as to whether there was any point of reference by which the gap between the moral and the military point of view on the H-bomb could be bridged; to which the V.C.A.S. replied that though they didn't pretend to be philosophers in the Service they were game to "have a go," and he believed that the maintenance of high moral standards was the only real answer. Air Chief Marshal Sir George Mills, referring to the moral issue, said that he had been brought up to believe that if you did wrong things you would be punished for them; but man had a free choice.

The second dramatic presentation, called "Maintaining the Deterrent," took the form of an Air Ministry conference attended by the Director of Operations (B. and R.), represented by W/C. P. G. D. Farr; the A. Cdre. Ops. Fighter Command (A. Cdre. P. G. Wykeham); G/C. Plans Bomber Command (G/C. D. C. Stapleton); and the D.D.G.W. (A), G/C. D. G. Smallwood. W/C. Farr emphasized that they were not trying to prove anything about the deterrent, but to show that the R.A.F. knew what it was doing and was quite confident about doing it. Discussion by the four officers covered the questions of readiness, by both Bomber and Fighter Commands, in the event of a surprise attack; the need for efficiency to make a deterrent force truly deterrent; the value of the stand-off bomb; the basic principles of the deterrent; defence against missiles; equipment of Bomber Command with missiles (after a possible replacement for the V-bombers); a guided weapon to augment Bloodhound; defence against missiles; and space flight research.

On defence against the low-flying bomber (one of the subjects raised in subsequent discussion), Air Chief Marshal Sir Thomas Pike, A.O.C-in-C. Fighter Command, said it was not possible at the moment to do much about it. Air Chief Marshal Sir Harry Broadhurst, A.O.C-in-C. Bomber Command, said his crews could react from the radar of Fighter Command almost as quickly as they could start up their engines.

### Facing the Future

After lunch the conference covered two subjects (in each case followed by a general discussion) under the headings "The R.A.F. Overseas" and "Facing the Future." The first took the form of an imaginary interview with A. Cdre. Rosier by a defence correspondent, their talk covering the whole gamut of R.A.F. work in 2nd T.A.F., M.E.A.F. and F.E.A.F., defining the primary aim of the overseas commands as the support of alliances and obligations under treaties, and emphasizing that when police action had to be undertaken it was never indiscriminate. The rôle of Transport Command was discussed and subsequently Air Marshal Sir Andrew McKee, its A.O.C-in-C., said that during the past two years it had never once failed to meet its commitments.

"Facing the Future" was dealt with under three headings — equipment, manning and finance. Speaking on the first, A.V-M. W. H. Kyle, A.C.A.S. (O.R.), said that the R.A.F. was developing "with the greatest possible urgency," its own ballistic missile; that it regarded the V-bomber with its guided bomb, and the ballistic missile, as complementary to one another; and that in order to keep the initiative, probably a second generation of these manned and unmanned weapons would be needed—and they would continue to be complementary to one another. It was not the R.A.F.'s intention to "cling to the idea that we need a bigger and better bomber as we know it now;" but a manned vehicle—something retaining discretion—and a ballistic missile capable of being launched without the inflexible ground organization needed now, might be the answer. Turning to defence, A.V-M. Kyle said that Hunters, Javelins and P.1s (the latter two both to be armed with Firestreak), Bloodhound and a development of Thunderbird should provide "an effective counter" to the manned threat to this country. It was the manned fighter which provided the "most difficult conundrum." Though it was officially decided a year ago that we would not develop another fighter, circumstances change rapidly; and if a reliable defence were found against the ballistic missile, "we could easily have a changed threat which would call for a long-range fighter designed to intercept, identify and destroy beyond the practical range of surface-to-air guided weapons."

A.V-M. Kyle finally turned to strategic transport aircraft, saying there was probably a need for a long-range large freighter, about which it was hoped that a decision might be made soon; then, referring to the R.A.F.'s needs overseas, he said that in the helicopter field there was a requirement to replace the Whirlwinds and Sycamores and there was a clear need for an aircraft of "the greatest possible flexibility" to replace the Canberra. Lastly, a fighter was required for tactical work overseas which was simpler, more economical and more versatile than the modern intercepter and some trials were being arranged in Aden. Underlying all these requirements, a strong research programme was necessary.

Manning was dealt with by A.V-M. D. M. T. Macdonald, the Director-General of Manning, who showed how it was proposed to have an all-regular Air Force with 120,000 airmen by the beginning of 1963 after the ending of National Service; and finance by Mr. R. H. Melville, a deputy under-secretary, in a brilliantly clear summary. Then, after a final discussion, Prospect Two was closed by an address from the C.A.S. in which he made four main points: the R.A.F. were ardent supporters of the deterrent; manned aircraft are required for as far as can be seen, because in war flexibility was needed and the nearer you could get a man to the target the longer you could use his brain; research was the life-blood of the R.A.F.; and the R.A.F. was fully conscious of the responsibility that rested on its shoulders.

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*Air Chief Marshal Sir Philip Joubert, who on April 24 presented a standard to No. 33 Sqn. at R.A.F. Leeming, seen (extreme left) with other former C.O.s and with the squadron's present commander, W/C. N. Poole (extreme right). From left to right the others in the group are A.V-M. F. P. Don; W/C. W. H. De W. Waller; Air Marshal Sir Hugh Walmsley; Air Chief Marshal Sir John Baker; G/C. J. Brodbury; G/C. J. H. McC. Reynolds; W/C. R. R. Mitchell; W/C. R. N. G. Allen; W/C. A. K. Furse; W/C. C. C. F. Cooper; S/L. N. P. W. Hancock; and W/C. R. C. Patrick. Behind the group is the No. 33 Sqn. "gharry" (in its pre-R.A.F. days a hearse), which is painted pale blue and bears the squadron badge.*

## SERVICE AVIATION . . .

### Naval Aviation Trends

THE helicopter's rôle in Naval anti-submarine activity may well be extended in future by the development of new methods of joint ship/helicopter operation. A project to continue trials made with the Fairey Ultra-Light helicopter operating from the deck of a frigate was mentioned by Capt. O. N. Bailey, Deputy to the Director of Naval Air Warfare, Admiralty, speaking on *Future Trends in Naval Aviation* before the Graduates' and Students' Section of the Royal Aeronautical Society in London on May 5. This new technique would take advantage of new, much-improved ship-borne sonar equipment.

Captain Bailey's lecture began with a summary of the Fleet Air Arm's present rôles and equipment. One particularly interesting point from this section concerned the effect of the introduction of the angled carrier deck: only one year after this introduction, an order for some 70 replacement Sea Hawks had been cancelled, such was the drastic reduction in landing damage and losses.

"The best seaborne radar in the world" was the lecturer's description of that fitted in H.M.S. *Victorious*, which could effect interception at altitude at ranges greater than ever before. The Type 984 scanner alone weighed over 20 tons (see the next item on this page).

For economy reasons the Navy could have only three carriers in operational service (two west and one east of Suez) in addition to any having long refits but including those undergoing the normal short dock period of three months every eighteen months. In addition, *Bulwark* would be used as a commando carrier for police and assault duties using helicopters. It was not yet known which type of helicopter would be employed; this would probably be the Wessex, or possibly the Westminster.

Listing the Navy's current aircraft types, Captain Bailey said that the M.D.A.P. Skyraiders were going out of service as A.E.W. (airborne early warning) aircraft "in the very near future" and were being replaced in this rôle by the Gannet Mk 3, which would carry an improved version of the U.S. search radar equipment. First of the Service's new aircraft was the Scimitar, due to enter squadron service on June 3 as a replacement strike aircraft with the ability to carry a nuclear weapon. The Sea Vixen all-weather fighter, which would come into service next year, would have a new type of British A.I. radar and carry Firestreak missiles.

Referring to the P.177 development of the Saunders-Roe SR.53 mixed power interceptor, the speaker recalled that the type had been accepted by the Naval Staff, and it had been agreed to get it into service, when the Minister of Defence decided that the country could not afford this machine on the basis of the limited number required by the Royal Navy. Without this aircraft, it was true that the Navy would feel the pinch, for the absence of the P.177 posed serious problems in dealing with high-altitude attacks by the newest and fastest aircraft.

The Blackburn NA.39 would in turn replace the Scimitar as a strike aircraft. The prototype had flown, on time, to a programme planned three years ago. Considerable assistance had been received from the U.S.A. in the instrumentation and boundary-layer control devices fitted to this machine. The NA.39 would be able to carry a nuclear weapon, and it could carry out an entire mission flying at sea level.

The types of operation envisaged for the aircraft carriers were primarily anti-submarine duties for those west of Suez and primarily strike and air defence east of Suez. In the event of hostilities it was expected that the British carriers would operate in conjunction with other allied fleets. One general problem in anti-submarine defence was the ability of a modern submarine to travel faster than the surface vessel which was attacking it—speeds of 40-60 kt were foreseen—and another problem was the advent of nuclear-powered submarines which were true submersibles and did not need to operate on the surface.

The Navy's existing carriers would finish their lives in the early 1970s. "We in the Navy," Captain Bailey emphasized, "see the use of manned aircraft for a considerable time to come." It was possible that the helicopter could be flown as a drone—but remote control of a helicopter landing on a frigate would not be achieved by 1970. "Until we get more effective ship-to-air guided weapons, we see manned aircraft continuing to be our defence against high- and low-flying enemy aircraft." Against low flying aircraft in particular, it was considered that manned aircraft would be superior to missiles for a very long time.

The carrier's value as a deterrent was great, and money would be needed soon to build new ones, the lecturer concluded.

During the informative discussion period which followed his lecture, Captain Bailey said that the radar equipment fitted in *Victorious* could handle more simultaneous raids than any previous carrier, and cost approximately £650,000 pounds. It was not expected that the Navy would operate helicopters much larger than the Wessex, which would carry anti-submarine homing weapons plus sonar detection gear. There was a requirement for all Naval aircraft to be capable of in-flight refuelling.

### "Fabulous" Radar

SPEAKING at a dinner of the British Institution of Radio Engineers in London on Thursday, May 1, the First Sea Lord, Admiral of the Fleet Lord Mountbatten, gave a description of the radar equipment—"of almost fabulous performance"—fitted in H.M.S. *Victorious*. This installation gives general long-range warning of the approach of enemy aircraft, and also provides accurate ranges, bearings and height data for the control of interceptions by the carrier's fighter aircraft.

The high-quality performance of the radar, a simultaneous Admiralty announcement stated, is obtained by means of a number of separate and narrow pencil beams. One of these, used for long-range warning, is fixed in elevation as the antenna rotates. The other beams scan contiguous vertical sectors in addition to rotating. The radio-frequency power is produced on centimetric waves by several very-high-power magnetrons.

In place of a conventional parabolic reflector, an advanced-design microwave lens is used to focus all the beams. This lens was constructed by spot-welding together a large and intricate arrangement of aluminium waveguides of differing rectangular cross-section and length. The antenna assembly, which includes transmitters and head amplifiers, weighs approximately 27 tons and is supported on a single deck-ring.

To make full use of the enormous mass of information obtained by the radar, a sophisticated display system is employed. This can process, store and filter the information so that it can be presented most comprehensively and comprehensibly to the officers making the tactical decisions. The system includes an intercept computer which gives the directing officer a future presentation of where and when an interception of the enemy would take place under his present directions to the fighter —which themselves have been computed for him.

A high level of efficiency has been achieved in the finished design, both technically and in the system's major contribution to the effectiveness of the ship's operations room. One interesting minor technical problem during development concerned the required display of certain information in the form of written characters on the face of a cathode-ray tube. Existing television methods were rejected in favour of a new system in which low-frequency waveforms and their derivatives are combined to "write" the characters in the same manner as Lissajous figures.

### IN BRIEF

A. V-M. C. R. Dunlap of the R.C.A.F. has been appointed Deputy Chief of Staff, Operations, at NATO H.Q.

* * * * *

Glasgow U.A.S. has won the Scone Trophy, competed for annually by the four Scottish university squadrons.

* * * * *

On the basis of information given by the Air Ministry, the name of the R.A.F. Director of the Joint Anti-Submarine School, Londonderry, was incorrectly stated in Part One of the article *Aircraft versus Submarine* in our April 25 issue. The R.A.F. Director of the Joint School is G/C. T. P. Seymour.

# S. F. CODY

## *A Personal Reminiscence*

By G. A. BROOMFIELD

**THIS year is the 50th anniversary of the climax, in 1908, of the great S. F. Cody's pioneer aeronautical work, when he became the first man in this country to make a successful powered flight in a heavier-than-air machine. In this article G. A. Broomfield, who knew and worked with Cody and has written a biography of that remarkable man, recalls his bold and imaginative experiments and designs. The article is also particularly apposite in the light of the current controversy on "Cody's tree" and the first powered flight in Britain—on which subject, in last week's issue, we printed a letter from the Director of the Royal Aircraft Establishment.**

SAMUEL FRANKLIN CODY spent twenty-five years of his life in Europe and, during that time, left an imperishable record in the annals of British Aviation. Initially laughed at and jeered at, he eventually became one of the most famous and beloved characters in this and many other countries.

The story of his life in America is outside the scope of this article; the only part of it with which we are concerned is that his father gave him a kite when he was three years old; and later on, when Cody became a cowboy-cum-buffalo-hunter, a Chinese cook taught him how to make and fly kites. I have already written the story of his early life in *Pioneer of the Air* (Gale and Polden, 1953).

After several previous visits Cody finally settled in England in 1888 and toured the British Isles and Europe with race-horses and a "Wild West Show," using kites to advertise his performances.

In 1901 he made his headquarters at the Alexandra Palace, London, and there constructed his first successful man-lifting kite. This he patented in that year, and incorporated in the controls was a wing-flexing device for preventing the series of kites yawing. The Wright brothers did not apply for their patent—for wing warping, plus rudder lateral control—until 1903.

Demonstrating these kites to the Navy at Portsmouth early in 1903, Cody flew over the Fleet at about 800ft, taking photographs and signalling results of gunfire. He thus became the first man to carry out aerial observations for the Navy, as balloons were not tried out until much later, and then only in calm weather.

Cody was unable to get an engine for his "aeroplane" until five years had elapsed; but meanwhile he built and flew a glider which had only one spar midway between the planes, the lower one having a gull-wing shape. It was fitted with ailerons for lateral control—this being, I think, the first time ailerons were used in a heavier-than-air machine. He flew the glider in the presence of Sir Hiram Maxim in 1905. The ailerons are clearly shown, beneath the lower mainplane, in the photograph below.

In 1904 he demonstrated his man-lifting kites to the Army at Aldershot—for aerial photography, reconnaissance, signalling, wireless and other purposes—in winds from ten to fifty miles an hour. (Balloons were being used by the Army—in winds below ten miles an hour.) As a result of the tests, the first Kite Section of the Royal Engineers was formed, with Cody as chief instructor.

He still continued gliding experiments over the Long Valley at Aldershot, and R.E. officers made many flights in his kites from Laffan's Plain, and on Army manœuvres, at altitudes exceeding 1,000ft. In 1905 Capt. (now Brigadier) P. W. L. Broke-Smith ascended to a height of over 3,300ft, which remains a world record for man-lifting kites.

Cody was next commissioned to design the control surfaces and fit the power unit to the dirigible balloon which was started by Col. Templer and finished by Lt-Col. (later Maj-Gen.) Sir John Capper. No British engine being available, Cody went to Paris and purchased a 50 h.p. Antoinette, which he duly installed. The airship, called the *Nulli Secundus*, was the first British Army airship to fly over London (in October 1907). On the way back it had to land at the Crystal Palace as the result of an adverse wind. Eventually the envelope was ripped to save the airship from complete destruction.

Meanwhile he had acquired a three-cylinder Buchet engine of about 12 h.p., and this he installed in one of his kites, suitably modified with a front elevator and tail and fitted with an undercarriage. After successful captive flights, it flew pilotless in 1907 from Farnborough Common for 4½ min.

Cody had made many applications, backed by Col. Capper, to construct a full-sized machine, and eventually the War Office allowed him the vast sum of £50 with which to build it. He again used the gull-wing design for the lower lifting surface, with the upper wing approximately straight. Jutting forward from the latter were three bamboo outriggers supporting a single elevator, which had a section cut in the centre to accommodate two bamboos from the engine-bearer. The outer struts had only piano wire to hold them in position from underneath.

*The glider at Long Valley, Aldershot, in 1905. Note the ailerons, below the bottom wing, and small rudder. Cody is in white.*

*Cody's first three-passenger flight, made on February 4, 1911: Left to right, Cody, the author, Miss Levette, J. W. Morton.*

No engine being available, Cody tethered his machine to the now-famous tree at Farnborough, and in strong winds was able to gain useful knowledge about the control surfaces.

The interplane struts were of streamline section. To decide the shape giving the least resistance, actual lengths of various struts were drilled at the top and threaded on to a steel rod. A three-bladed extractor fan, three feet in diameter, was used to obtain an airflow of about 40 m.p.h. in a small wind tunnel. The base of the section Cody used actually moved forward during this experiment, whilst the rest were blown backwards.

He worked out the pitch of his propellers by using a straight-edge and a chalked triangle on the floor. The spade-shaped blades were slid on to the arms of a T-shaped tube, and fixed by bolts and setscrews; at the single end of the "T" was the driving sprocket. Cody thus evolved the first adjustable-pitch propeller.

Finally, while the *Nulli Secundus* airship was being rebuilt, he managed to obtain permission to use its Antoinette engine. It was installed in April 1908, and again the tree was used. This time the aeroplane was tethered from the tail, and a spring balance inserted in the rope between tree and aircraft, to measure the thrust of the propellers. First Cody used a vee belt on the starboard side, and a double-vee (or "long hexagon" section) belt—to allow for it being crossed—on the port side; but such belts, even when doubled, proved too weak for the power, and after the first five flights were discarded in favour of the chain-and-sprocket from the airship. One chain was crossed (being taken through tubes filled with tallow) to allow the propellers to revolve in opposite directions.

The most level piece of land available was the clearing on Cove Common, used by the Royal Engineers for their horses. It was about 400 yd long, and dotted about with water troughs.

On May 16, 1908, the first attempt to fly was made. Cody had fitted his machine—apparently to obtain more lift—with a sort of sail, triangular in shape, stretching from the rudder to the wings. This was later removed as it was found to be useless. On the day of the test he used wing-warping for lateral control, having removed the detachable balancers fitted to the base of the bottom outer rear strut, which he had previously used to gain some idea of the controls required when the machine was tethered to the tree. These were refitted in June or July, after the elevator had folded up, but were again discarded in September.

The utmost secrecy was maintained at the Balloon Factory, especially between Cody and J. W. Dunne. Whenever Dunne

wished to experiment with his model gliders in the airship shed, he did so while Cody was at lunch. Reporters were not allowed, and *The Times* was the only paper to notice the daily events in May 1908, by calling them "rolling experiments."

Starting up his engine for the May 16 flight, Cody opened the throttle, and the machine increased its speed for about 200 yd, when the wheels were seen to be just clear of the ground. He then switched off to avoid running into the trees.

Paced between the marks of the wheels on the grass, the length of the hop was found to be 50ft. Cody then flew back, increasing the length. He made another flight to the end of the clearing, and again flew back, each flight being longer than the previous one. The fifth flight (all were made on the same day) was over 150ft in length, at a height of between eight and ten feet. This was approximately the same length as the first flight in the world—a distance of 120ft—made by Orville Wright at Kitty Hawk, North Carolina, on December 17, 1903.

Cody was very excited at his success and, to give himself a longer run, rashly taxied too near the trees, and smashed his machine into a water trough. He never used the clearing again.

At a lecture given to the Aeronautical Society later in 1908 he said: "I have accomplished one thing I hoped for very much; that is, to be the first man to fly in Great Britain. . . . I made a machine that left the ground the first time out; not high, possibly five or six inches only. . . . I made some five flights in all, and the last flight came to grief."

These flights, which were observed by the officers and men of the Balloon School and Factory of the Royal Engineers, were the first in the British Empire. J. A. D. McCurdy, who flew in the United States early in 1908, did not make his first flight in Canada (at Baddeck) until February 23, 1909, so therefore Cody was, without doubt, the first, both in Great Britain and in the Commonwealth, to fly over British territory.

Men of the Balloon and Kite Companies, including a Naval detachment, helped to take the machine back to the airship shed. Repairing the damage, Cody attempted another flight at the end of May, but dived into the ground after hitting a ditch. He next tried to fly from Farnborough Common, but the front elevator folded up and the machine was damaged. At this juncture, fearing that their engine would be wrecked, the Army took it from Cody and re-installed it in the *Nulli Secundus 2*. Trials of the airship were unsuccessful, and it never flew after June 24, 1908.

Col. Capper now forbade Cody from making any further attempts to fly until he had thoroughly mastered the controls and had more "rolling practice." This explains his letter and his silence about previous attempts. By now he had strengthened his outriggers, replacing the wires with bamboos; and as soon as he had managed to obtain the engine again he made what he called "the most talented flight the machine did—it flew uphill." Moving to Jersey Brow, opposite the Queen's Hotel, Farnborough, he flew 78 yd in September; and after three "runs" of from half to three-quarters of a mile on September 24, he made a flight of 496 yd on October 5, 1908, which was terminated by a smash, caused by Cody steering into the cant of the aeroplane—as on a bicycle—instead of the reverse. The machine had been struck by a gust.

He rebuilt the machine, fitting balancing flaps on each side of the elevators. He also attached tapes to the trailing edges of all his lifting surfaces. He discovered that a nose-dive followed a stall, and photographs were taken of what happened to the tapes during the stall.

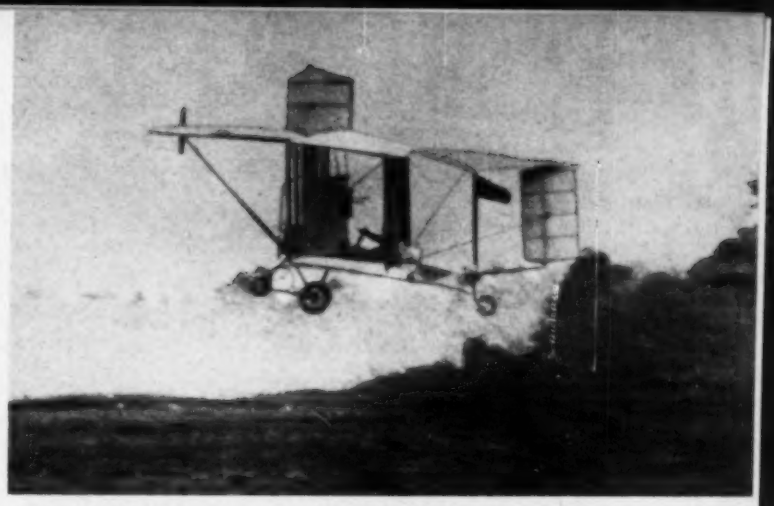
Next he fitted a biplane tail,* and made many flights during the early part of 1909. A cutting through the trees having been made, between the Balloon Factory and Laffan's Plain, he began flying there. Now, however, the Press started a campaign, calling him a "bluffer," and his machine an "agricultural implement."

Though handicapped by lack of funds and encouragement from the Government, and hurt by the jeers, Cody still doggedly persevered, and eventually persuaded his machine to do a complete circuit of Laffan's Plain. The Prince and Princess of Wales—later King George V and Queen Mary—were staying at the Royal Pavilion at Aldershot at the time. They were told of the flight and immediately went over to the Plain, to see Cody make his first "command flight." This terminated when the machine struck a ridge while doing a banked turn. From then on the Prince was a staunch friend of Cody and visited him on several occasions. This was the first circular flight in England, but it did not qualify for the £1,000 prize offered by the *Daily Mail*, as Cody was an American and his engine French.

The War Office, however, having contributed £2,500 towards the experiments of Cody and Dunne, terminated both their engagements. Cody was given the wrecked machine, minus engine, and was granted permission to fly it (if he could) at the Fleet end of Laffan's Plain. At that time the War Office still owed him for his kite patents, and only after protracted legal arguments, which swallowed up most of the money, was Cody awarded £5,000 for his work at the Balloon Factory.

A similar thing happened to the Wrights. They, incidentally, wrote to Cody claiming that he had infringed their patents. Upon Cody pointing out that he had used wing-warping on his kites before they had applied for their famous patent, the matter was allowed to drop. Orville, Wilbur and Katharine Wright came to Jersey Brow in 1909, and I have a snap of Cody and Col. Capper showing Orville where he flew from in 1908.

*The librarian of the Royal Aero Club at Londonderry House has drawings of this machine made in February 1909.*



***Cody making his fifth flight, at Farnborough on May 16, 1908. This was over a distance of 50 yd and was witnessed by the Superintendent of the Balloon Factory (Col. J. E. Capper) and officers and men of the Balloon and Kite sections of the Royal Engineers.***

At the other end of Laffan's Plain Cody completely rebuilt his aeroplane, discarding the biplane tail, and fitting twin side-by-side front elevators, which operated either in unison or in opposite directions, thus serving as balancers in addition to the ailerons on the rear struts. He obtained a French E.N.V. engine of 60 h.p. and was very soon carrying passengers, the first of whom was Col. Capper and the second Mrs. Cody. This was on August 15, 1909. On September 8, 1909, he flew for over an hour across country at a height of from 600-800ft. This was a world record, and he became a national hero.

He flew his machine at the first Doncaster Meeting in October 1909, where he was naturalized, signing papers brought out by the Town Clerk, and, trying for a prize of £1,000 in a flight from Liverpool to Manchester, he was forced down at Prescot through fog and crashed when attempting to take off.

That winter he built the famous "Bournemouth" machine, which became "the first airliner." Originally designed for two 60 h.p. Green engines, driving one propeller, it flew at the Bournemouth meeting in July 1910 and then at Lanark, with only one engine. Winning the second Michelin Cup that year, it flew with three passengers—myself and another standing on the wings, with a lady in the seat. I was also the "weight" on the wings, when Cody demonstrated that "it balances well."

At the Bournemouth meeting the speed record was won at about 51 m.p.h. When Cody fitted the machine with the horsepower (120) it was designed for, it flew with four passengers at 70 m.p.h. Had this happened at Bournemouth, the greatest prizes in aviation would have fallen into his lap.

Next year he built the "Circuit of Britain" machine, which was the only British aircraft to finish. It was also the only biplane to complete the course. The engine was a 60 h.p. Green. This machine won two Michelin Trophies in 1911. When rebuilt and fitted with the 120 h.p. Austro-Daimler from the monoplane specially built for the competition (and which crashed during the test flights) it won the Military Trials held on Salisbury Plain in 1912 to decide the best machine for the newly formed Royal Flying Corps.

These trials were open to the world's foremost manufacturers and pilots, backed by unlimited funds; but Cody by his pluck, perseverance and wonderful piloting beat them all and won the first prize of £5,000.

The War Office only ordered one copy of this machine from Cody and this is now in the care of the Science Museum at South Kensington (though it is not at present on exhibition).

Next year he built a waterplane for the Sea Circuit of Britain. Cody carried many passengers in it when it was fitted with a land undercarriage. On August 7, 1913, the machine broke up in the air, killing Cody and his passenger W. H. B. Evans. Personally I have always believed that the four-bladed propeller burst, knocking out one of the struts; but as the blades were never found, this theory could not be confirmed.

Cody was often confused with Col. W. F. Cody, the celebrated "Buffalo Bill"; but never, until King George V so addressed him, did he use the title "Colonel."

His death caused universal sorrow, and the funeral in the Military Cemetery at Aldershot was attended by over fifty thousand people, the Navy, Royal Flying Corps and every regiment in the Army being represented.

# CORRESPONDENCE

*The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. The names and addresses of the writers, not for publication in detail, must in all cases accompany letters.*

## A.C. *versus* D.C.

I WOULD like to record how much I agree with Mr. Hill's article, "Electrical Systems in the Air," in your issue of May 2. He has at least one other in step with him.

He puts a case for a matter which I have plugged in the industry at the risk of growing tiresome. My repeated remark that "you have much to learn about A.C.," has so often been met by rather pitying looks as if to say that "Old Brookie is off on his hobby horse again."

From the aircraft operator's point of view, whether he be military or civil, the great advantage of the use of A.C. is the simplicity and reliability of the squirrel-cage motor, but this is the only outstanding advantage.

I have yet to be convinced that an A.C. installation is overall lighter or more reliable than a D.C. system or that it can be made so. The vast sums spent since the war on the development of A.C. for aircraft, put against the disappointing and inconclusive results, should point a lesson.

Blandford Forum, Dorset. F. BROOKESMITH.

## Surveying Airliner Markets

READING with interest Roger Bacon's column "Straight and Level" in the April 11 issue of *Flight*, I was struck by one particular item—the last paragraph. [How the managing director of a firm studying the executive market had not heard about the Grumman Gulfstream—Ed.]

Before undertaking any project in the business aircraft market, all parties concerned should thoroughly evaluate the competition and prospects. Untold millions have gone down the drain in ill-advised projects. As you well know, market requirements continually change—and a 1958 need is not necessarily filled by a 1960 airplane.

I am enclosing information concerning the market survey our firm did for the Gulfstream and a brief brochure about the application of market research to aviation planning.

Incidentally, I enjoy columns such as Roger Bacon's, since they tend to represent an independent viewpoint rather than the official viewpoint of formal news releases.

Lindenhurst, New York. PETER E. VIEMEISTER, Viemeister Associates, Inc.

## Man or Missile ?

I WOULD like to take up the linguistic point recently quoted by your contributor Roger Bacon when discussing the stone dropped from the Tower of Pisa.

It would be mistaken, in deriving missile from *mitto*, to assume an essential connection with the idea of propulsion, because the basic meaning of *mitto* is no more than "to let go." Ballistic, however, from $\beta\acute{\alpha}\lambda\lambda\omega$, is more definitely connected with the forceful projection of an object.

Perhaps, then, the stone would strictly be merely a missile. The hypothetical man who jumped would be a ballistic missile.

London, S.W.3. A. P. LLOYD.

## The Grade Monoplane

I HAVE been interested in the correspondence in your columns regarding the Grade monoplane of 1913 because I have hoped that somebody with first-hand knowledge of this machine would come forward to explain the reason for wheels being mounted above the wings. I have been intrigued by this rather strange fitting for some time and in the absence of definite information I have formed a theory that this particular machine was intended for an attempt at "landing" against the under-side of a Zeppelin.

This theory is not as wild as at first sight appears. At about the same time as this machine was produced the Germans had successfully launched a Rumpler Taube from the Zeppelin *Schwaben*. There is no doubt that they must have considered the possibility of being able to recover the machine in flight and in such an attempt one of the greatest difficulties would be to prevent damage to the fabric of the Zeppelin by the pylon carrying the landing wires. All monoplanes of that period were, of course, externally braced and cantilever wings were not in use. It was, therefore, necessary to have a pylon above the fuselage and a similar pylon below the fuselage unless the flying wires were attached to the undercarriage. I cannot accept for one moment that the Grade machine was intended to land upside down deliberately, as the tailwheel was not repeated above the fuselage.

Quite apart from the duplicate wheels the machine was of great design interest. The fuselage (if such it could be called) was a simple A-frame, the apex carrying the tail surfaces and the legs forming the motor bearers. The pilot was accommodated in a seat suspended at about the position of the cross member. Simple though this construction was the fuselage had no strength in the vertical plane—unlike more conventional designs which, whether covered as in most tractor designs or uncovered as in pusher designs, were wire-braced within themselves to provide rigidity. In the Grade design a large X-frame of steel tubes was placed symmetrically at a point just forward of the pilot's seat. The simple A-frame forming the fuselage was then wire-braced fore and aft from this X-frame. In addition, the flying and landing wires radiated from the extremities of the X-frame and the lower two legs were joined by an axle carrying the normal landing wheels. The upper two legs were also joined and it is to that joining strut that the additional wheels were added.

The later type, which was known as the "1914 type" and also as the "Militareindecker" and was illustrated in *Deutschlands Eroberung der Luft* published in 1915, used a similar tail-boom arrangement, but the pilot was situated in a "pod" hung below the wing to which the landing wheels were attached direct. Four struts connected the "pod" to the wing and were carried through in pyramid formation to a point above the wing from which wire bracing radiated fore and aft and athwartships to the wings. The corresponding bracing radiated from the bottom of the "pod."

Hutton, Essex. F. SMITH.

## Unsung Heroes of 1914-18

REFERRING to Mr. Austin's letter [March 21] on unsung heroes of 1914-18, I would like to add the late Air Marshal Conyngham's name to the list.

Nobody ever thinks of the B.E.2C, A.W. and R.E.8 types. Capt. Glennie, M.C., D.F.C., comes to my mind, I remember him as a flight commander in No. 7 Sqn. (R.E.8) and Capt. Carberry of No. 59 Sqn., who captured a whole German battery in September 1918 at Achiet-le-Petit, thereby originating No. 59's crest—a broken wheel.

There are many more pilots and observers of the Art. Obs. Squadrons deserving of song.

Penzance, Cornwall. E. C. D. MALONE.

## Naming the P.1

IT is rather surprising that the English Electric P.1, which has been flying for some considerable time and is to become the R.A.F.'s standard fighter, has not so far been given a name.

I would suggest that it should be known as the Excalibur. This would commemorate a famous weapon of superlative quality and the alliteration of "English Electric Excalibur" would sound rather well.

Liverpool 18. D. P. JONES.

## FORTHCOMING EVENTS

May 16. Institute of Navigation: "Principles of Inertial Navigation Systems," by E. W. Anderson.
May 21. Kronfeld Club: Debate, "The Golden Age of Gliding has now Passed."
May 24-26. Belgian Aero Club: Brussels Exhibition Rally.
May 24-26. Fréjus-St. Raphaël Aero Club: Provence Wines Rally.
May 25-June 1. Aéro Club de l'Ouest: d'Angers Gliding Competition.
May 25-26. S.M.A.E.: National Model Contest, R.A.F. Waterbeach.
May 26. R.A.F.A.: Display, Hucknall.
May 26. Tiger Club: Sandown Race, I.o.W.
May 26-27. Canadian Aeronautical Institute: a.g.m., Toronto.
May 28. Kronfeld Club: "Cambridge University Gliding Club," by John Pringle.
May 29. The Royal Society: "The Institute of Aviation Medicine," by G/C. W. K. Stewart.
May 29-June 1. R.Ae.C.: International Invitation Rally, Shoreham.
June 1. Royal Belgian Aero Club: International Balloon Meeting.
June 1-3. Aéro Club de France: Helicopter Rally.
June 4. Kronfeld Club: Lecture by David Ince.
June 6. Helicopter Association: "Turbine Helicopters," by D. L. Hollis Williams.
June 7-8. Aéro Club de France: Normandy Rally.
June 7. Helicopter Association: Garden Party and Rally, Dunsborough Park, Ripley, Surrey.
June 8. Royal Dutch Aero Club: Balloon Trophy Competition, Rotterdam.
June 8. Wolverhampton Aero Club: Members' Competition Day.
June 14. Plymouth Aero Club: Air Display.
June 14-15. Popular Flying Association: Rally, Rhoose, Cardiff.
June 15-29. World Gliding Championships, Poland.
June 18. Kronfeld Club: "The Early Days," by F. N. Slingsby.
June 20-23. Lerida Aero Club: International Tour of Pyrenees.
June 20-23. Palermo Aero Club: Tour of Sicily.
June 21. R.N. Air Station Ford: At Home.
Sept. 1-7. S.B.A.C. Display and Exhibition, Farnborough.

# To what far horizons?

He's at home in his small world. A house, a garden, a few streets, are the limits of his experience. But he's learning fast, and every day enlarges his horizon.

Like him, we are growing in experience; as the work of the International Geophysical Year goes forward, so does our knowledge of our home, the Earth. And with knowledge our achievement, too, will grow—to who can tell what far horizons?

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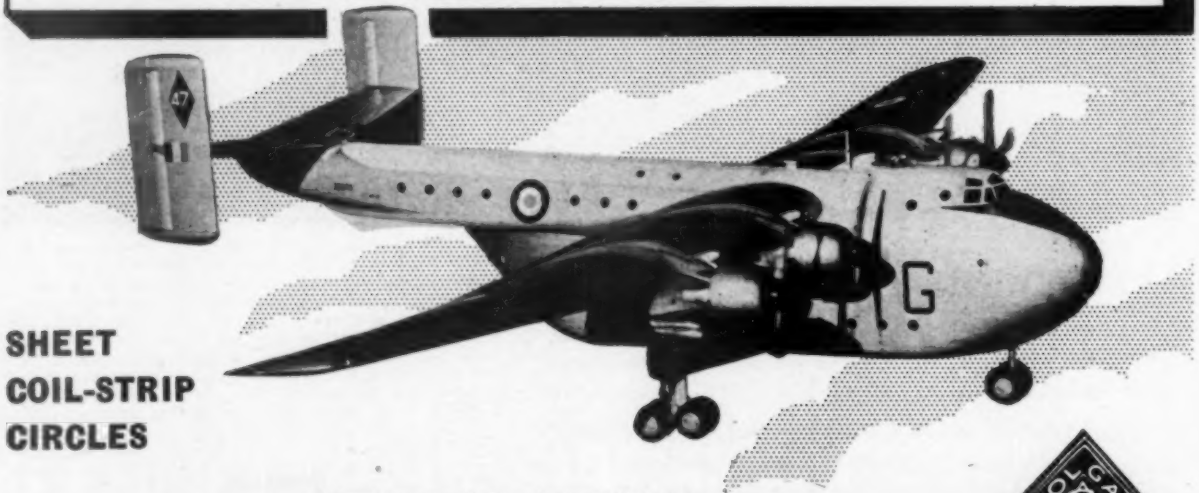

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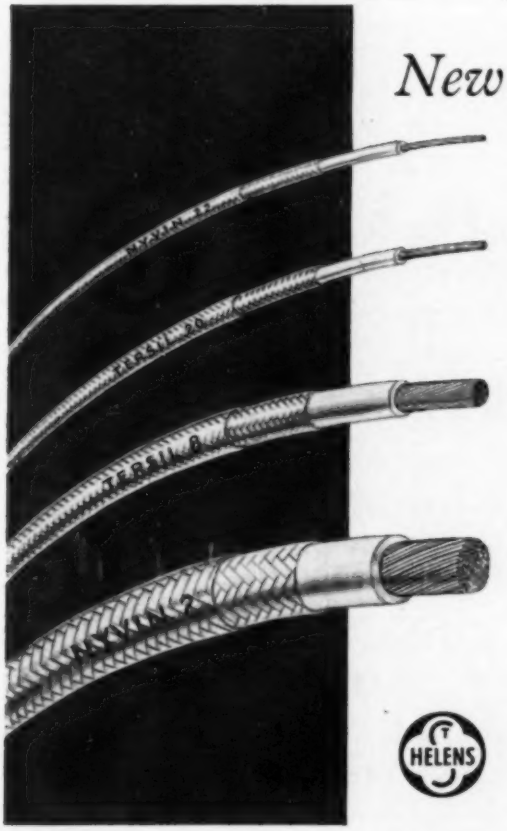

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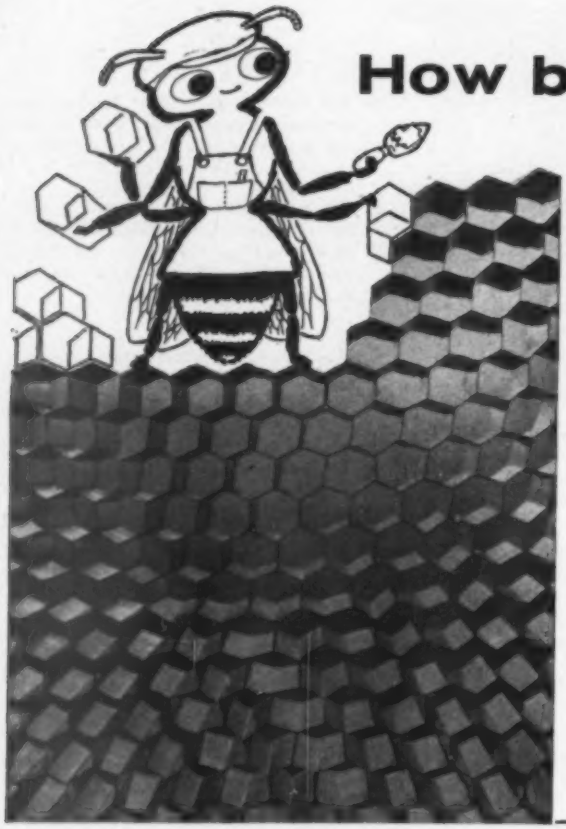

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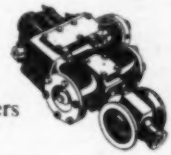

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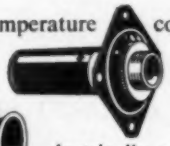

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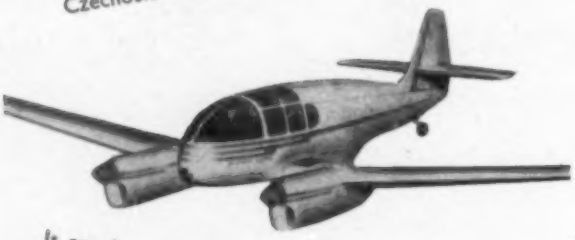

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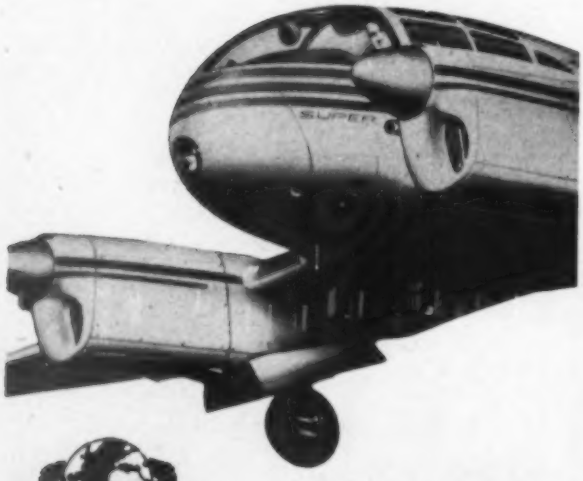

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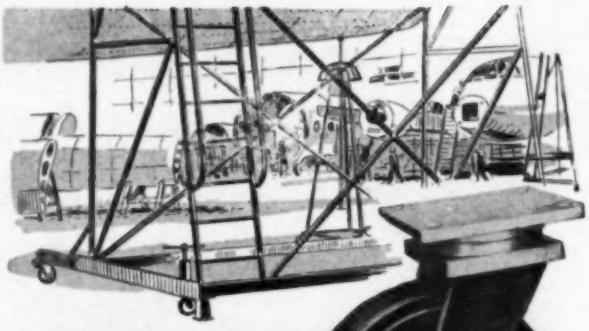

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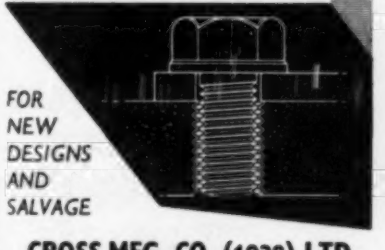

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THIS application will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on July 30, 1952. Any representations or objections with regard to this application must be made in writing, stating the reasons, and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the application may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [7889

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**Technical engineers:** For work on dynamics, aerodynamics or structures. Applicants should have honours degrees in maths, aeronautical engineering or physics.

Experience in missile control techniques, guidance, hypersonic flow, high-speed flutter derivatives, or performance analysis an advantage.

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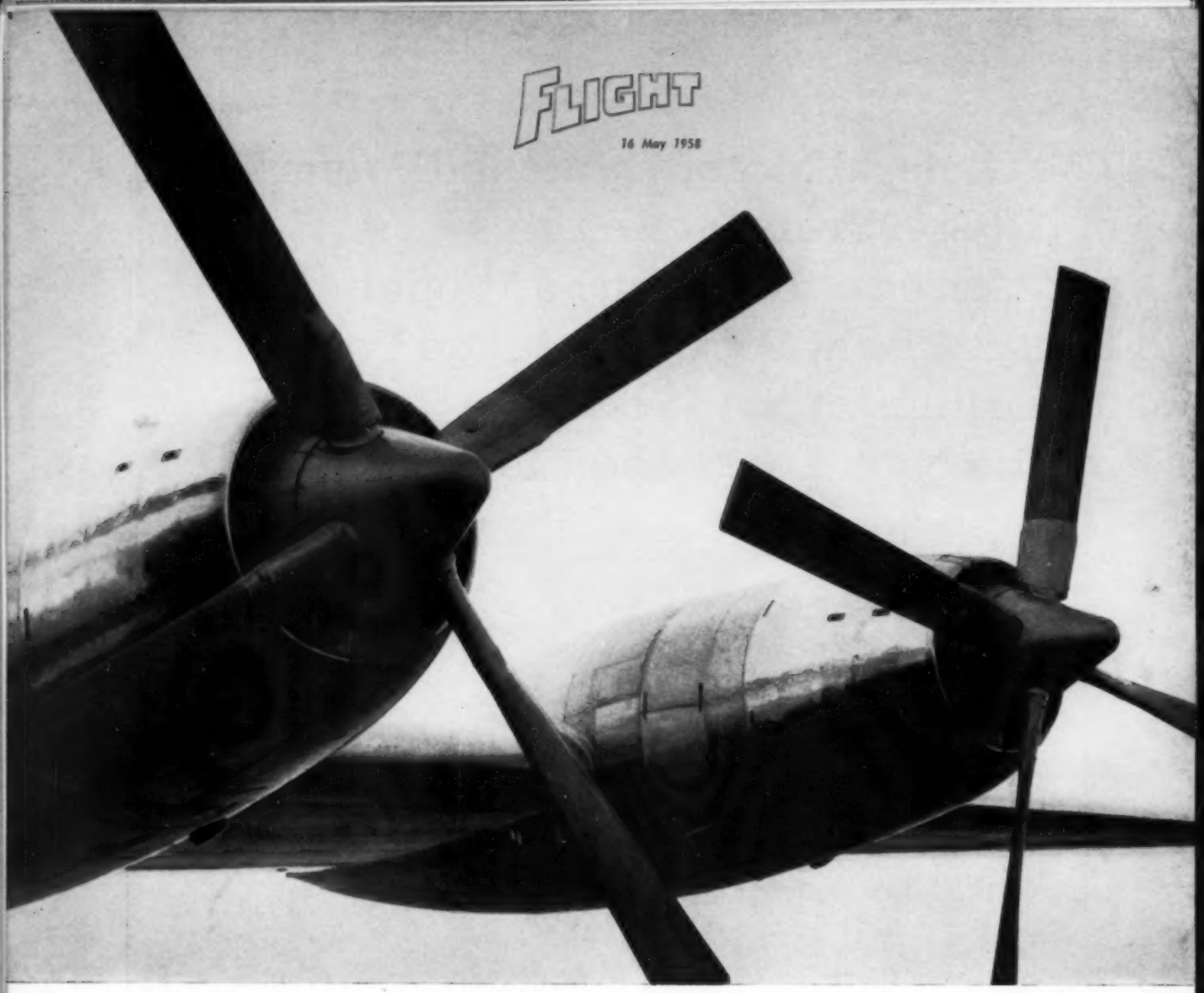

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